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CONCEPTUAL DESIGN REPORT FOR REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE, VOLUME II TECHNICAL INFORMATION DOCUMENT

BOOK 4 OF 5

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

JANUARY 1994

REV. 0

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

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Conceptual Design Report, for Remedial Action at the Chemical Plant Area of the Weldon Spring Site, Volume II Technical Information Document

Book 1 of 5 contains Sections 1-5

Book 2 of 5 contains Sections 6-12

Book 3 of 5 contains the figures for all sections

Book 4 of 5 contains the tables for all sections

Book 5 of 5 contains Appendix A, Unpublished Documents, and Appendix B, Acronyms

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Weldon Spring Site Remedial Action Project

Conceptual Design Report, for Remedial Action at the Chemical Plant Area of the Weldon Spring Site, Volume II Technical Information Document

Tables

Book 4 of 5

Revision 0

January 1994

Prepared by

MK-FERGUSON COMPANY
and
JACOBS ENGINEERING GROUP
7295 Highway 94 South
St. Charles, Missouri 63304

for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

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Table 1-1 Tentative Sequence of CDR Activities

Activity	Description	Comment
General Site Activities		
1. Construction of the CMSA	Clear and prepare the CMSA area to store borrow material.	Concurrent with activities 2, 3, 4, and 5.
2. Waste removal	Clear the area in the footprint of the disposal cell; activity will continue in other areas as the cell is constructed.	Concurrent with activities 1, 3, 4, 5, and 6.
3. Waste handling and transportation	Transport the waste removed by Activity 2 to storage areas and eventually to the disposal cell.	Concurrent with all other activities.
4. Site roads	Prepare the access roads; this activity will continue as the cell is constructed.	Concurrent with all other activities.
5. Site drainage	Provide the storm drainage system; this activity will continue as access roads are moved.	Concurrent with all other activities
6. Borrow materials	Provide borrow material for the foundation of the cell; this activity will continue as construction of cell and roads require borrow material.	Concurrent with activities 2, 3, 4, and 5.
(Refer to the Disposal Cell)		
Waste Treatment and Processing Activities		
CSS or VIT plant, size reduction, dewatering decontamination, additional treatments	Construct and test the plant and related treatment and processing operations; various operations related to the treatment and processing activity.	Concurrent with all other activities. Plants designed and tested prior to initiation of waste treatment.
Disposal Cell Activities		
7. Cell foundation	Prepare the disposal cell foundation.	Concurrent with activities 2, 3, 4, 5, and 6.
8. Liner and leachate collection and removal systems	Place the liner and leachate collection and removal systems.	Concurrent with activities 2, 3, 4, 5, and 6.
9. Waste placement	Place the waste in the disposal cell, in accordance with the placement plan.	Concurrently with the treatment plant output and waste removal and transportation.
10. Waste containment system	Construct the cover and the clean-fill dikes as waste is placed in cell.	Concurrent with most activities.
11. Operation and maintenance	Operate and maintain the cell during placement activities.	Concurrent with the cell construction and waste placement.

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Table 1-1 Tentative Sequence of CDR Activities (Continued)

Activity	Description	Comment
12. Site closure	Remove temporary structures used to construct the cell; construct permanent roads and other structures; seed, and close the site.	Final construction activity.
13. Long-term monitoring and maintenance	Perform monitoring and maintenance activities periodically, as described in the post-closure plan.	Post-closure activity.

TABLE 2-1 Estimated Areas and Volumes of Contaminated Media

Material Type	Location	Estimated Volume (yd³)
Contaminated soils and sediments	Frog Pond Ash Pond North Dump South Dump Chemical plant building area Raffinate pit dikes and clay bottom Vicinity properties	7,000 8,200 7,600 16,900 76,300 153,500 23,600 293,100
Rubble	Raffinate Pit 4	500
Concrete building foundations and underground piping	Chemical plant building area	41,639
Stored materials (includes stockpiled contaminated soils)	Temporary storage area Material staging area Ash Pond spoils area Mulch pile ACM storage area Building 434	94,349 52,085 56,193 29,132 10,069 309 242,167
Sludges	Raffinate pit Site water treatment plant Quarry water treatment plant Quarry sludges	220,000 3,100 500 4,100 227,700
Total Chemical Plant Operable Unit Wastes		805,105
Project-Generated Wastes (contaminated haul roads, aggregate surfaces, PPE, etc.)	Site-wide	123,043
Estimated Total Waste Volume		928,148

Source: Material Waste Quantities Report January 1, 1992 - March 31, 1992, Material Waste Quantities Report July 1, 1992 - September 30, 1992, and recent (1993) volume estimates.

TABLE 3-1 Results of Modified Value Engineering

Evaluation Criteria (Weight from MVE)	List Alternatives (Final Ranking)	Advantages/Disadvantages	Preferred Alternative

TABLE 3-2 Observational Method

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design

TABLE 3-3 Data Quality Objectives

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities

TABLE 4.2-1 Soil Cleanup Criteria

Contaminant	Criteria	ALARA Goal
Ra-226	6.2 pCi/g	5 pCi/g
Ra-228	6.2 pCi/g	5 pCi/g
Th-230	6.2 pCi/g	5 pCi/g
Th-232	6.2 pCi/g	5 pCi/g
U-238	120 pCi/g	30 pCi/g
Arsenic	75 mg/kg	45 mg/kg
Chromium (total)	110 mg/kg	90 mg/kg
Chromium (VI)	100 mg/kg	90 mg/kg
Lead	450 mg/kg	240 mg/kg
Thallium	20 mg/kg	16 mg/kg
PAHs	5.6 mg/kg	0.44 mg/kg
PCBs	8 mg/kg	0.65 mg/kg
Trinitrotoluene (TNT)	140 mg/kg	14 mg/kg

TABLE 4.3-1 Primary Contaminants for the Weldon Spring Site

Radiological Parameters	
U-238	Gross alpha
Th-230	Gross beta
Th-232	Gamma radiation
Ra-226	

Organics	
Nitrobenzene	2,4,6-Trinitrotoluene (TNT)
2,4-Dinitrotoluene (2,4 DNT)	Polychlorinated biphenyls (PCBs)
2,6-Dinitrotoluene (2,6 DNT)	

Inorganics/Metals/Asbestos		
Cadmium	Zinc	Nitrate
Chromium	Molybdenum	
Lithium	Arsenic	
Magnesium	Manganese	
Mercury	Barium	
Nickel	Beryllium	
Vanadium	Sulfate	
Iron	Fluoride	
Lead	Asbestos	

TABLE 4.3-2 Potential Sources of Contaminants at the Weldon Spring Site

Nitrates

Nitric acid recovery plant (Area 100)
Digestion and denitration plant (Building 103)
Refinery tank farm (Area 102)
Spills from above areas
Process line and sewer leaks
Past management practices
Raffinate pits sludge
Nitric acid used in production of TNT/DNT
Spills and poor waste management practices during the World War II production effort

Sulfates

Raffinate pits sludges which contain sulfates
Sulfuric acid used in production of TNT/DNT

Fluoride

Green salt plant (Building 201)
Green salt farm (Area 202)
Metal pilot plant (Building 404)
Raffinate pits sludge

Metals

Metals plant (Building 301)	Magnesium
Magnesium building (Building 302)	Magnesium
Metal pilot plant (Building 404)	Lithium
Raffinate pits water	Chromium
Raffinate pits water	Nickel
Raffinate pits water	Vanadium

Organics

Metals plant (Building 301) tanks
Ordnance production—toluene storage tanks
Building 105-tributyl phosphate separation

Source: (Ref. 40)

TABLE 4.3-3 Waste Disposal at the Weldon Spring Quarry

Date	Material	Quantity
1942-1945	Nitroaromatics and residues Quarry used for TNT/DNT waste disposal.	unknown
1946	Nitroaromatics and residues	90 tons
1946-1957	TNT residues Residues and rubble dumped in deepest part of quarry and in northeast corner.	unknown
1959	Thorium residues Disposal of drums containing 3.8% thorium residues. Estimated Ra-228 content of 0.25 Ci.	185 yd^3
Early 60's	Building rubble, equipment, soils Demolition rubble from Destrehan Street Plant. Covers approximately one-acre to 30 ft deep in the deepest part of the quarry. Contains uranium and radium contamination with less than 1 Ci Ra-226.	50,000 yd^3
1963-1965	Thorium and uranium residues Several thousand drums containing thorium and rare earths from Granite City Arsenal. Initially intended for disposal. Much of waste later removed for reprocessing.	unknown
1966	Thorium residues Drums and residues from shutdown and cleanup of Weldon Spring Chemical Plant process equipment.	unknown
1966	Thorium residues Hundreds of drums brought from Cincinnati by rail. Contain 3% thorium with estimated 1 Ci Ra-228. Placed above water level.	555 yd^3
1966	TNT/DNT residues Contaminated stone and earth dumped in northeast corner of quarry covering the Cincinnati thorium residues.	unknown
1968-1969	Uranium and thorium residues Contaminated building rubble and process equipment from Weldon Spring Chemical Plant. Principal sources of radioactivity are Ra-226 and Ra-228.	5,560 yd^3

Source: (Ref. 28)

TABLE 5.1.2-1 Contaminated Material Types, Locations and Volumes

Material Type	Location	Estimated Volume (yd^3)
Contaminated soils and sediments	Frog Pond Ash Pond North Dump South Dump Chemical plant building area Raffinate pit dikes and clay bottom Vicinity properties	7,000 8,200 7,600 16,900 76,300 153,500 23,600 293,100
Rubble	Raffinate Pit 4	500
Concrete building foundations and underground piping	Chemical plant building area	41,838
Stored materials (includes stockpiled contaminated soils)	Temporary storage area Material staging area Ash Pond spoils area Mulch pile ACM storage area Building 434	94,349 52,095 56,193 29,132 10,089 309 242,167
Sludges	Raffinate pit Site water treatment plant Quarry water treatment plant Quarry sludges	220,000 3,100 500 4,100 227,700
Total Chemical Plant Operable Unit Wastes		805,105
Project-Generated Wastes (contaminated haul roads, aggregate surfaces, PPE, etc.)	Site-wide	123,043
Estimated Total Waste Volume		928,148

Source: Material Waste Quantities Report July 1, 1992 - September 30, 1992, Material Waste Quantities Report January 1, 1992 - March 31, 1992, and recent (1993) volume estimates.

TABLE 5.1.2-2 Waste Removal Alternatives

Material Type	Removal Alternative
Raffinate pit sludges	Dredge with slurry pump and pipeline** Sump pump with slurry/pipeline Draglin/Sauerman scraper Dewater/remove/haul Remove/containerize/haul
Raffinate clay bottom material and dikes*	No acion** Binder Gravel-base or geosynthetic roadways** Offset removal
In-place soils/sediments	Backhoe** Fron-end loader** Self-loading scraper**
Building foundations	Hoe ram** Concrete saw Concrete shear** Expansive cement
Underground utilities	Backhoe** Crane** Manual
Stockpiled materials	Backhoe** Front-end loader** Crane**

* Removal equipment the same as for in-place soil/sediment. Alternatives evaluated are for CSS alternatives if the material cannot support equipment weight.

** Preferred alternative.

TABLE 5.1.2-3 Results of Modified Value Engineering: In-Place Soils/Sediments Removal

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
System-wide suitability - optimize equipment use on numerous waste locations. Dust reduction and control. Meet health and safety guidelines, including OSHA requirements. Operational flexibility - flexibility to adapt to changed or new conditions. Minimize contaminant spread by limiting contact between clean and contaminated soils. Meet required production to satisfy waste placement requirements.	Track backhoe/trucks.	**Advantages:** Can work from above or at bottom of excavation. Equipment and trained operators readily available. Applicable to operations requiring more precise excavation. Suitable for system-wide use; can be used for various removal requirements, but may not be as efficient in all cases. Can work on wet and low-bearing soil. Can load trucks at either top/bottom of excavation. Can handle debris that may be encountered. Compatible with health and safety. **Disadvantages:** Not as appropriate for shallow excavation. Not as mobile as other equipment types.	For small, deep and isolated areas, use backhoe and truck. For small, shallow and isolated areas, use front-end loader or backhoe and truck. For large, deep areas, use: Dry - combination of self-loading scrapers, front-end loaders with trucks, and backhoe with trucks. Wet - backhoe with trucks. Large, shallow contaminated areas; use self-loading scrapers or wheeled front-end loaders if contamination spread cannot be controlled for scrapers.
	Wheel front-end loader/truck.	**Advantages:** Mobile. Equipment and trained operators readily available. Appropriate in shallow excavation. Excellent for removing material from stockpiles. Compatible with health and safety. **Disadvantages:** May require dozer support. Does not work well on wet soils and low-bearing soils. Must work from bottom of cut.	

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TABLE 5.1.2-3 Results of Modified Value Engineering: In-Place Soils/Sediments Removal (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Self-loading scrapers	**Advantages:** Appropriate for excavation of large areas. Loads and hauls, optimizing equipment use. Mobile. Compatible with health and safety. **Disadvantages:** More potential for contaminant spread from hauling. Cannot operate in excavations containing debris. Not appropriate for detailed confined, excavations; needs a large area to operate. Not appropriate for excavations with highly irregular boundaries. Cannot remove materials from stockpiles. More dust emissions, although emissions easily controlled through wetting.	

TABLE 5.1.2-4 Results of Modified Value Engineering: Raffinate Pit Clay Bottom Material Stabilization

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Amount of dust generated and the ability to control any dust. Production rates that meet project schedule. Impact on treatment plants ability to produce satisfactory product. The flexibility to adjust to conditions encountered. Minimize waste by not contaminating clean material. The ability of the equipment to operate on the waste material. Health and safety of the workers and general public. Flexibility to change production rates to meet schedule requirements.	Stabilize with binder/excavate and remove.	**Advantages:** Increases removal equipment choices. Controls dust. Significantly increases equipment workability and productivity once mixed. Could positively impact treatment. **Disadvantages:** Additional equipment needed for mixing. Could negatively impact treatment. Longer prep time to mix binder. Sequential mixing required; top third and bottom two-thirds of clay bottom must be kept separate. Added material to be disposed of.	No prep pending material conditions. Gravel-based roadway. Low ground pressure equipment. Offset. Binder.
	Gravel-based roadways/excavate with backhoe.	**Advantages:** Won't impact treatment. Lesser lead time for preparation. Suitable for all material conditions. Good removal schedule flexibility. Significantly increases equipment workability and productivity. **Disadvantages:** Added dust control needed. Increases waste. FEL and scraper can't be used.	

TABLE 5.1.2-4 Results of Modified Value Engineering: Raffinate Pit Clay Bottom Material Stabilization (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Offset removal from previously removed area.	**Advantages:** No increase to waste. No prep time. Good equipment workability. **Disadvantages:** Initial pass needs extended arm backhoe to reach from dike. Removal flexibility decreased; must remove material in strips. Low productivity due to flat angle of repose. FEL and scraper can't be used. Difficult dust control of working face.	
	Use low ground pressure equipment.	**Advantages:** Reduced preparation. No additional waste. **Disadvantages:** Specialized equipment with limited use other than liners. Reduced productivity over standard equipment.	
	No material preparation.	**Advantages:** No added waste. Same equipment as used elsewhere. No preparation required. **Disadvantages:** Unknown if clay bottom will allow equipment to operate.	

TABLE 5.1.2-5 Results of Modified Value Engineering: Building Foundations

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Reduce adverse public perception. Dust and contaminant control. Operational considerations: - Range of application (slabs, footings, etc.). - Production rates within schedule requirements. - Ability to produce size requirements of the rubblized concrete. Compatible with health and safety requirements.	Hoe ram	**Advantages:** Readily available. Suitable for a wide variety of reinforced concrete foundations. Required size control can be achieved. Safety; operator distanced from operation. Good productivity. **Disadvantages:** Reinforcing bar must be cut separately.	Use hoe ram on everything; cut reinforcing bar with shears.
	Concrete shear	**Advantages:** Safety; operator distanced from removal. Size control can be achieved. Will cut reinforcing bar. **Disadvantages:** Not as applicable for slab removal. Applications are primarily for superstructure removal.	
	Saw	**Advantages:** Reinforcing bar does not need to be cut separately. Minimizes rubble generation. **Disadvantages:** Water needed during process; drainage control and water treatment required. Safety; operator not distanced. Less applicable to vertical surfaces. Slow production.	

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TABLE 5.1.2-5 Results of Modified Value Engineering: Building Foundations (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Expansive cement.	**Advantages:** Safety - maximizes operator distance. No dust generated. **Disadvantages:** Limited application. Slow production.	

TABLE 5.1.2-6 Foundation Types Present

Building or Area No.	Foundation Type						Elevations (ft)			
	Piers	Spread FTG's	Grade Beams	Slab on Grade	Sump Pit Walls	Retaining Walls	Average Building Exterior	High Point	Maximum Bottom	Item Footprint Dimension
B-101	51	51	3	2	1		661	661	643	102 x 122
A-101		1	1	1	1		659	660	654	
A-102A_a	16	17	1				668			60 x 60
A-102A_b	9	9	1				668	669	656	30 x 50
B-102B	12	15	3				659	663	662	43 x 51
B-103	104	104	1	1	1		662	661	656	122 x 256
B-104	6	2	1	1			661	661		17 x 27
A-104				1 1	1 1			660 658		
B-105	55	55	1	16	15		660	661	650	102 x 182
A-105	6	6				2		662		
B-106				2	8		659	660	646	12 x 12
B-108	12	12	1	1			661	664	655	44 x 66
A-108			1	1	1			663	656	
B-201	97	97	1	1	1	1	660	660	652	194 x 175
B-202	75	75	1	1	1	1	660	662	646	
B-301	101	111	1	1	1			659	635	

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TABLE 5.1.2-6 Foundation Types Present (Continued)

Building or Area No.	Foundation Type						Elevations (ft)			
	Piers	Spread FTG's	Grade Beams	Slab on Grade	Sump Pit Walls	Retaining Walls	Average Building Exterior	High Point	Maximum Bottom	Item Footprint Dimension
B-401	96	96		1	1		659	659	638	174 x 322
B-403	90	30	1	1			649	651	641	107 x 107
B-404	37		1	1	1		650	651	623	80 x 172
B-405A	12		1	1			650	651	643	32 x 61
B-405B				1				650	647	62 x 65
A-405A				1				650		
A-403				1				650		
A-404				1				650		
B-406	17	17					664 660 658			63 x 131 18 x 237 18 x 237
Continuous		1	1	1		1		664	655	
B-407	88		1	1	1		654	655	626	162 x 29
B-408	99	99	1	1		1		657	648	193[8] x 361[8]
B-410	92	92	1	1				665	645	256 x 312
B-412	4		1	1			658	659		22 x 49[4]
B-413	44	6	1	1	1		659	662	652	39[6] x 101
B-414		12	1	1			660	661	659	62 x 102
B-417	11	11	1	1	1		657	657	655	63[4] x 67[4]

TABLE 5.1.2-6 Foundation Types Present (Continued)

Building or Area No.	Foundation Type						Elevations (ft)			
	Piers	Spread FTG's	Grade Beams	Slab on Grade	Sump Pit Walls	Retaining Walls	Average Building Exterior	High Point	Maximum Bottom	Item Footprint Dimension
A-426	6	6		1	1		658	659		$20^4 \times 21^9$
B-428		4	1	1			659			70 x 95
B-429		1	1	1			658	656 659	652	28 x 25
B-430		1	1	1			655	655		24 x 26
B-431			1		1	1	654	665	643	12 x 12
B-433	20	20	1	1			667	667	656	40 x 182
B-439		1.		1			666			12 x 14
B-441		1	1	1		1	659	661		70 x 80

TABLE 5.1.2-7 Results of Modified Value Engineering: Underground Utility Removal

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Compatible with health and safety requirements.	Backhoe	**Advantages:** Soil and utility can be removed using same equipment. Operator distanced from removal site. Flexibility provided to meet OSHA excavation regulations. Good production rate. Able to handle various sized pipes. Common use. **Disadvantages:** None.	Backhoe
	Crane	**Advantages:** Operator distanced from removal site. Able to handle various sized pipes. **Disadvantages:** Cannot remove soil with crane. Production rates slower because of equipment addition. Workers <u>are</u> required in trench to hook crane regardless of pipe sizes.	
Multiple use capability of the selected equipment. Able to handle various sized pipes, including large pre-stressed concrete. Production rates optimized to reduce cell construction time.	Manual	**Advantages:** More careful removal ability if no breakage desired. **Disadvantages:** Can't handle larger sized pipe. More stringent requirements to meet OSHA excavation regulations. Questionable productivity. Health and safety not optimized. Still require equipment. Not good in deeper trenches.	

TABLE 5.1.2-8 Underground Utility Types
AREA: SOUTHWEST

Underground Utilities														
Type Pipe or Structure	Structures Quantity	Pipe Diameter (in.)												
		4	6	8	10	12	15	15	18	21	24	30	36	54
		Pipe Length (ft)												
P			525	420	260	195	260					830		
SS			180	625	66	355	355		400	65	60			
SAN			295	530										
CWU		180												
FWU			590	165	60	1970					600			
PWU		770						675				140		
ORD						110								
Fire Hydrant	10													
Manhole	7													
Catch Basin	14													

SAN Sanitary Sewer
P Process Sewer
SS Storm Sewer
PWU Potable Water Underground
FWU Fire Water Underground
CWU Cooling Water Underground
ORD Ordnance Water Underground

TABLE 5.1.2-8 Underground Utility Types (Continued)
AREA: SOUTHEAST

Underground Utilities														
Type Pipe or Structure	Structures Quantity	Pipe Diameter (in.)												
		4	6	8	10	12	15	16	18	21	24	30	36	54
		Pipe Length (ft)												
P		280	760											
SS						50	170		745		495	95		
SAN			710	470	805									
FWU		370	460	695	500	1450								
PWU		115	765		640			905						
Fire Hydrant	5													
Manhole	10													
Catch Basin	13													
Skimmer Tank	1													

SAN Sanitary Sewer
P Process Sewer
SS Storm Sewer
PWU Potable Water Underground
FWU Fire Water Underground

TABLE 5.1.2-8 Underground Utility Types (Continued)
AREA: NORTHEAST

Underground Utilities															
Type Pipe or Structure	Structures Quantity	Pipe Diameter (in.)													
		3	4	6	8	10	12	15	16	18	20	21	24	30	36
		Pipe Length (ft)													
P		160	276	247	430										
SS			60	125	230	127	140	195	350	565	85	240	260	115	795
SAN				925	500	322									
CWU			90	70	120	477									
FWU			1020	1197			1504						588		
Fire Hydrant	9														
Manhole	12														
Catch Basin	13														
Yard Drain	3														
Septic Tank	1														
Sand Filter	1														

SAN Sanitary Sewer
P Process Sewer
SS Storm Sewer
FWU Fire Water Underground
CWU Cooling Water Underground

TABLE 5.1.2-8 Underground Utility Types (Continued)
AREA: NORTHWEST

Underground Utilities															
Type Pipe or Structure	Structures Quantity	Pipe Diameter (in.)													
		3	4	6	8	10	12	15	16	18	21	24	30	36	64
		Pipe Length (ft)													
P				440	150		195	260		260		410	375		
SS				80	275	35	269	970	65	815		528		120	
SAN				822											
CWU			450	170		865	120								
FWU				556	386	475	295					1340			
PWU		625	1431												
ORD				120			495								
Fire Hydrant	8														
Manhole	13														
Catch Basin	15														
Septic Tank	1														
Sand Filter	1														

SAN Sanitary Sewer
P Process Sewer
SS Storm Sewer
PWU Potable Water Underground
FWU Fire Water Underground
CWU Cooling Water Underground
ORD Ordnance Water Underground

TABLE 5.1.2-8 Underground Utility Types (Continued)
AREA: ASH POND

Underground Utilities														
Type Pipe or Structure	Structures Quantity	Pipe Diameter (in.)												
		4	6	8	10	12	15	16	18	21	24	30	36	54
		Pipe Length (ft)												
SS			225						330		75		60	125
ORD					395	762								
Fire Hydrant	1													
Manhole	1													
Outlet Chamber	1													

SS Storm Sewer
ORD Ordnance Water Underground

TABLE 5.1.2-8 Underground Utility Types (Continued)
AREA: RAFFINATE PIT

Underground Utilities														
Type Pipe or Structure	Structures Quantity	Pipe Diameter (in.)												
		4	6	8	10	12	15	16	18	21	24	30	36	54
Pipe Length (ft)														
P			256	470										
SS							66							
PWU												1180		
ORD						350								
Manhole	1													

P Process Sewer
SS Storm Sewer
PWU Potable Water Underground
ORD Ordnance Water Underground

TABLE 5.1.2-8 Underground Utility Types (Continued)
AREA: TEMPORARY STORAGE AREA (TSA)

Underground Utilities															
Type Pipe or Structure	Structures Quantity	Pipe Diameter (in.)													
		2 1/2	4	6	8	10	12	15	16	18	21	24	30	36	54
		Pipe Length (ft)													
SS															
FWU															
PWU													900		
ORD							250								
Fire Hydrant	1														
Septic Tank															
Distribution Box															

SS Storm Sewer
PWU Potable Water Underground
FWU Fire Water Underground
ORD Ordnance Water Underground

TABLE 5.1.2-8 Underground Utility Types (Continued)
AREA: SITE WATER TREATMENT PLANT (SWTP)

UNDERGROUND UTILITIES															
Type Pipe or Structure	Structures Quantity	Pipe Diameter (in.)													
		1	4	6	8	10	12	15	16	18	21	24	30	36	54
		Pipe Length (ft)													
P															
SS															
SAN				120											
CWU		70													
FWU					452										
PWU															
Fire Hydrant	1														
Manhole	5														
Septic Tank	1														
Distribution Box	1														

SAN Sanitary Sewer
P Process Sewer
SS Storm Sewer
PWU Potable Water Underground
FWU Fire Water Underground
CWU Cooling Water Underground

TABLE 5.1.2-8 Underground Utility Types (Continued)
AREA: FROG POND

UNDERGROUND UTILITIES														
Type Pipe or Structure	Structures Quantity	Pipe Diameter (in.)												
		4	6	8	10	12	15	16	18	21	24	30	36	54
		Pipe Length (ft)												
SS									160					
ORD					655									
Fire Hydrant	1													

SS Storm Sewer
ORD Ordnance Water Underground

TABLE 5.1.2-9 Results of Modified Value Engineering: Stockpile Removal

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Equipment suitability to material being removed (size and material type).	Front-end loader	**Advantages:** Good for removing smaller sized material such as soil; rubble 3 ft and under; chipped wood. Good contaminant spread control. Good productivity. No ancillary equipment needed. **Disadvantages:** Not suitable for large ⌀ pipe, bulky metals, or baled materials. Needs some maneuvering room.	For soils, wood, and small rubble: FEL - if maneuvering room available.
	Backhoe with grapple	**Advantages:** Good for removing bulky and large-sized material. Optimizes maneuvering room. Better productivity than crane. **Disadvantages:** Could overturn equipment if too large a piece is picked-up. Poor contaminant spread control if used for soil and small rubble. Slower productivity than front-end loader.	
Production rates matching waste placement requirements. Minimize contaminant spread by limiting spillage. Compatible with health and safety regulations.	Crane	**Advantages:** Can pick up large individual pieces. More suited to removing materials from the top of high stockpiles. **Disadvantages:** Low productivity. Increased health and safety concerns (overturning and cable tieing on). Only suitable for the listed advantages.	Backhoe - in tight areas. Bulk and large size: Backhoe with grapple unless stockpile too high. Crane for high stockpile. Extra large and heavy: Crane.

TABLE 5.1.2-10 Raffinate Pit Material Quantities

Pit	Water (Gal.) x 100	Sludge (yd^3)	Soil (pit dikes and clay bottom) (yd^3)
1	1,564	17,400	7,000
2	1,564	17,400	7,000
3	9,698	129,600	50,000
4	43,156	55,600	89,500

Source: Materials Waste Quantities Report January 1, 1992 - March 31, 1992, Material Waste Quantities Report July 1, 1992 - September 1992, and recent (1993) volume estimates.

TABLE 5.1.2-11 Results of Modified Value Engineering: Raffinate Sludge Removal

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Control radon and airborne particulate emissions by retaining water cover during the excavation operation. Control contamination spread by reducing the amount and location of sludge spills. Achieve production rates compatible with treatment plant operation. Compatible with water management needs including site water treatment. Compatible with overall site sequencing and schedule.	Cutter-head dredge with slurry pump and pipeline.	**Advantages:** Good radon and particulate emission control; raffinate pit water does not need to be removed and serves as controlling agent. Water management is flexible; equipment can be easily moved so that localized low points are not created. Use of cutter head dredge produces a pumpable slurry; separate equipment components are not required. Equipment is mobile and easily moved; little downtime due to setup and moving. Variable pumping rates available; production easily controlled. Systematic pattern for removal can be developed. **Disadvantages:** Trash and debris must be removed by another process. Cannot observe material being removed; care must be taken so that clay bottom is not breached.	Dredge/slurry pump with pipeline.

TABLE 5.1.2-11 Results of Modified Value Engineering: Raffinate Sludge Removal (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Dragline/Sauerman scraper.	**Advantages:** Can handle most debris that may be encountered. Maintains water cover to control radon and dust emissions. **Disadvantages:** Extremely sloppy/high contaminant spread. High potential for leaving a significant amount of sludge because of inability to see through water cover. Requires alternate process to remove material adjacent to dikes. Need to construct numerous perimeter access ramps and staging areas. Requires separate rehandling and transporting processes.	
	Sump pump/slurry.	**Advantages:** Good radon and particulate emission control. Raffinate pit water does not need to be removed and serves as the controlling agent. **Disadvantages:** More water management required; the sump location will create a low point. Care must be taken that enough water is always available to cover all material. A significant amount of cover water would be delivered to the dewatering facility. Numerous sump pump equipment relocations required. Requires added process step. Separate material collection and agitation is necessary to feed pump. Sporadic production rates: material intake is variable because of mechanical material collector inefficiency; downtime occurs to allow for equipment relocation.	

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TABLE 5.1.2-11 Results of Modified Value Engineering: Raffinate Sludge Removal (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Dewater pits; control emissions; excavate and haul.	**Advantages:** Equipment being used to remove in-place soils and stockpiled materials can be used. Common earthmoving equipment could be used. **Disadvantages:** Particulate and radon control poor. Controlling agent (water, foam) must be applied over large areas; water application will create sloppy work conditions. Water <u>must</u> be removed prior to material removal, possibly causing schedule delays. Poor contamination control: high interstitial moisture content of sludge will cause material to readily spread out over large areas and seep out of removal equipment.	
	Excavate from barges, containerize, and haul.	**Advantages:** Pumping not required. Reduces water consumption since removal is not by slurry. Good radon and particulate emission control. **Disadvantages:** Possible RCRA storage area may be needed to temporarily store filled containers. A larger temporary storage area is needed. Production rate poor. Unconsolidated layers may be difficult to remove. Increased waste volume for disposal. Increased material handing requirements. Large labor crew needed.	

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TABLE 5.1.2-12 Observational Method: Raffinate Sludge Removal

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Dredge/slurry with pump.	Dredge can remove material.	Dredge cannot remove material.	Low	Fatal — need alternate method.
	Material is pumpable.	Material not pumpable.	Low to medium	Fatal — need alternate method.
	Enough water available for emission control.	Not enough water.	Low	Implement other control methods; i.e., foam cover, plastic cover.
	Production rates can be met.	Unable to meet production requirements.	Low	Add equipment.

TABLE 5.1.2-13 MSA Material Groups and Sorting

Material & Storage Area Type	In-Place Volume (yd^3)	Maximum Storage Volume (yd^3)	Remarks
Place Intact • Vehicles • Engine blocks • Air handling • Exhaust fans • Lathes • Coring equipment • Blending vessels • Other similar type equipment	1,145	80,000 (12,000 optional fill in)	1. 20 ft vertical height stacked on drainage. 2. Place on dunnage. 3. Plug, cap, or flange openings. 4. Watertight storage for at least 6 yr.
Stainless Steel • Stainless steel - Tanks - Equipment - Structural members - Pipe - Sheeting	60	8,900	
Non-Shreddable • Pipe > 12 in. ϕ with fittings, valves, appurtenances removed	160	18,200	1. 8-ft lengths. 2. Split in half.
Product Process Pipe • Product process pipe	160	2,000	1. 8-ft lengths. 2. Roll-off boxes.
Shreddable • Pipe < 12 in. ϕ with fittings, valves, appurtenances intact • Miscellaneous metals - Pipe fittings - Electrical connectors - Castings - Valves - Bolts - Nuts - Small pieces of equipment - Short curved piping - Sag rods - Reinforcing steel - Fence posts/fencing	1,400	50,000	1. 8-ft lengths. 2. Flatten all equipment made primarily of sheet metal. 3. Size flatten sheet metal in 4-ft x 8-ft pieces.

TABLE 5.1.2-13 MSA Material Groups and Sorting (Continued)

Material & Storage Area Type	In-Place Volume (yd^3)	Maximum Storage Volume (yd^3)	Remarks
• Sheet metal - Metal desks - File cabinets - Supply closets - Lockers - Ductwork - Control boxes - Man-doors • Plate steel - Corrugated steel siding - Corrugated steel roofing - Metal decking - Towers - Tanks - Vessels - Plate - Expanded metal decking			
<u>Trash and Miscellaneous Non-Metals Area</u> • Non-metal debris - Plastic - Glass - Paper products - Floor scrapings - General trash - Collected debris (housecleaning) • Miscellaneous non-metals - Graphite pipe - Graphite sheeting - Diatomaceous earth <u>Double bag, label bag "radioactive material," place in roll-off boxes and label roll-off boxes as "bagged material"</u> • Non-metal debris - Housecleaning HEPA vacuum dust	360	3,960	1. Place in roll-off boxes.
<u>Transite Siding</u> • Nonfriable ACM - Siding sheets	260	9,000	1. Band in 4-ft bundles; stack on dunnage.
<u>Miscellaneous Transite</u> • Nonfriable ACM - Miscellaneous nonfriable ACM • Shielding sheeting • Partitions • Other types of ACM			

TABLE 5.1.2-13 MSA Material Groups and Sorting (Continued)

Material & Storage Area Type	In-Place Volume (yd^3)	Maximum Storage Volume (yd^3)	Remarks
Deconneble • Structural steel - Columns - Beams - Crane rail - Girts - Purlins • Railroad rails	4,600	26,000	1. Approximate 30 ft lengths or 2. Maximum 5000 lb weight limit. 3. Remove projections to within 1 ft of steel shades.
Wood • Large wood pieces - Telephone poles - Railroad ties - Wood desks - Chairs - Coat racks - Man-doors - Partitions - Miscellaneous wood materials • Wood (special) - Cooling tower (Bldg. 413)	580	1,283	1. Sort bolt connections, bolts, and nuts from wood. 2. The current plan is to remove wood from MSA; chip and store at mulch pile.
Aluminum • Metals (special) - Aluminum • Siding • Deck plate • Structural shapes	70	412	
Copper • Copper - Bus bars - Wire conductors - Wire in motors • Conduit with Wire - Wire in conduit	230	2,800	

TABLE 5.1.2-14 Vicinity Property Summary

VP Identification	Volume (yd^3)	Area (ft^2)	Depth (ft)	Primary Contaminant	Concentration (wt. average) pCi/g	Represented Under Operable Unit	Comments
Army Property 1							
Buried mound	415	2,600	4	U-238	678	Chemical plant	
Northern & western mound perimeter	440	4,755	2.5	U-238	75	Chemical plant	
Exterior zone	180	8,703	0.5	U-238	22	Chemical plant	
Railroad tracks	111	1,200	2.5	U-238	38	Chemical plant	Removed during haul road construction.
Drainage ditch	19	1,000	0.5	U-238	Not Estimated.	Chemical plant	
Army Property 2							
Zone 1	31	837	1	U-238	20	Chemical plant	
Zone 2	26	1,404	0.5	U-238	18	Chemical plant	
Zone 3	50	1,350	1	U-238	96	Chemical plant	
Zone 4	71	3,834	0.5	U-238	28	Chemical plant	
Zone 5	6	108	1.5	U-238	78	Chemical plant	
				Ra-226	18		
Army Property 3 DA3	46	825	1.6	U-238	62	Chemical plant	
Army Property 5	900	8,000	3	Ra-226	Not Estimated.	Chemical plant	ORAU estimated 30 pCi/g further characterization needed.
Army Property 6	730	6,600	3	U-238	Not estimated	Chemical plant	Further characterization needed estimate based on ORAU data volume. PMC estimated on U-238 at 15 pCi/g using ORAU data.
Busch Property 3							
Area A	3	72	1	U-238	161	Chemical plant	
Area B	7	42	4.5	U-238	228	Chemical plant	

TABLE 5.1.2-14 Vicinity Property Summary (Continued)

VP Identification	Volume (yd^3)	Area (ft^2)	Depth (ft)	Primary Contaminant	Concentration (wt. average) pCi/g	Represented Under Operable Unit	Comments
Busch Property 4 Area A	9	168	1.5	Ra-226 U-238	23 15	Chemical plant	
Area B	2	130	0.5	Ra-226 U-238 Th-232	6.49 6.08 1.34	Chemical plant	Not an average. One sample taken.
Area C	240	6,468	1	Ra-226 U-238 Th-230	118 13 44	Chemical plant	
Busch Property 5	1			Th-230	110 (Highest concentration found)	Chemical plant	Four barrels. PMC remediated May 1988. Material removed and placed in 20 drums in Building 434 (3 are overpacked). Resurveyed in November 1988.
Busch Lake 34	8,000			U-238 (?)		Chemical plant	
Busch Lake 35	5,000			U-238 (?)		Chemical plant	
Busch Lake 36	7,000			U-238 (?)		Chemical plant	

TABLE 5.1.2-15 Waste Removal Design Criteria Requirements

Definition of contamination boundary limits and depths.
Definition of contaminant types requiring removal including locations, quantities, and acceptable erosion and sedimentation control methods.
Surface water control requirements; temporary and permanent.
Identification of buried debris; locations, types and quantities.
Geotechnical investigation results.
Backfill requirements.
Grading requirements.
Borrow sources.
Survey control points.
Monitoring well locations; protected, abandoned and relocation.
Temporary facility requirements; decontamination pads; barricades.
Excavation sidewalls sloping requirements.
Location of underground utilities to remain.
Equipment type and size restrictions, if any.
Contaminant removal level criteria.
Special dewatering considerations; handling of contaminated liquids.
Revegetation requirements.
Acceptable emission control methods.
Access restrictions.

* These are general requirements; material-specific requirements are described in the text.

TABLE 5.1.2-16 Waste Removal Specifications

Specification	Soils	Foundations/ Utilities	Raffinate Sludge	Raffinate Clay Bottom	Vicinity Properties	Stockpiles
Facilities and Decontamination					x	
Emission Control	x	x	x	x	x	x
Surface Water Control	x	x	x	x	x	x
Dewatering	x	x	x	x	x	
Site Preparation and Grading	x	x	x	x	x	
Earthwork	x	x		x	x	
Site Restoration	x	x		x	x	
Demolition		x				
Well Abandonment	x					
Underground Utility Removal	x	x				
Removal Sequencing	x	x	x	x	x	x
Dredging			x			

TABLE 5.1.3-1 Preferred Handling and Transportation Equipment

Material Type	Location	Handling Equipment	Transport Equipment
Containerized	ACM Storage MSA TSA SWTP QWTP Building 434	* Crane Crane Forklift Forklift Forklift	* Flatbed Flatbed Flatbed Flatbed Flatbed
Mulch	Mulch Pile	Front-end Loader	Rear-end Dump
Metals Small Large	MSA TSA	Front-end Loader Crane	Rear-end Dump Flatbed
CSS Product • Soil-like • Grout	Treatment Facility	Front-end Loader Pump/Pipeline	Rear-end Dump Concrete Mixer
VIT Product • Frit	Treatment Facility	Front-end Loader	Rear-end Dump

* Function of asbestos handling and transport regulatory requirements.

TABLE 5.1.3-2 Handling and Transportation Design Criteria

Equipment decontamination requirements.
Applicable regulatory agency transport requirements.
Special handling and transport requirements and restrictions.
Haul route identification.
Material to be handled and transported including type, size and quantity.
Delivery restrictions, if any.
Access restrictions, if any.
Equipment restrictions, if any.
WSSRAP Environmental, Safety & Health Considerations.

TABLE 5.1.3-3 Handling and Transportation Specification List

Specification	Soils	Foundations/ Utilities	Raffinate Sludge	Raffinate Clay Bottom	Vicinity Properties	Stockpiles
Emission Control	x	x	x	x	x	x
Material Sorting/Segregating	x	x	x	x	x	x
Material Transport • Truck • Slurry Pipeline	x	x	x	x	x	x
Water Management			x			
Temporary Material Storage	x	x	x	x		
Traffic Regulation	x	x		x	x	x

TABLE 5.1.4-1 Results of Modified Value Engineering: CMSA Site Preparation

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]	Advantages/Disadvantages	Preferred Alternative
1. Location – Off-site Clay Borrow			
Adequate size of storage area (18.0).	Borrow Source. 1 An area at or adjacent to the off-site borrow source, southeast of Francis Howell High School.	**Advantages:** Easy delivery of products for processing. No interference with site operations. Keeps operation in one area. Minimizes operational and maintenance costs. Minimizes delivery distance. Minimizes worker safety. Minimized congestion. Conducive to efficient operation. **Disadvantages:** Distance to disposal facility for recovery. Proximity to Francis Howell High School.	Store and process off-site clay borrow material at the borrow source.
Area has adequate size to store 50,000 yd³ off-site clay borrow.	North of Ash Pond (CMSA). 2 Area currently proposed as CMSA, north of Ash Pond.	**Advantages:** Space can be easily obtained. More convenient for recovery. Easiest to construct. **Disadvantages:** Consumes valuable site space. Requires independent processing equipment. Additional on-site activities. Limited space.	

TABLE 5.1.4-1 Results of Modified Value Engineering: CMSA Site Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]	Advantages/Disadvantages	Preferred Alternative
Public perception (7.0). Public acceptance of storage site location including impact on Francis Howell High School local traffic patterns and environment. Worker safety (20.0). Minimize the incident of worker exposure to accidents. Ease of recovery (12.0). Minimize the length and difficulty of the route from the storage facility to the disposal cell and related costs. Minimize impact on other activities (9.5). Locate to avoid other construction activities. Ease of storage area construction (2.5). Minimize clear and grub, utility development, security, grading and drainage, and environmental impact. Ease of land acquisition (18.5). Land can be obtained for use <u>prior</u> to and <u>during</u> disposal cell construction period.	Marshalling Yard. drop Area adjacent to the quarry haul road at old railroad staging area south of Weldon Spring Chemical Plant. Disposal Cell Siting Area. Within the disposal cell siting area currently defined, northern portion.	**Advantages:** Minimal development impact. Land availability highly likely. **Disadvantages:** Distance to disposal facility for recovery. More interference with site activity. Requires independent processing equipment. Most difficult to construct. Requires additional new development. Worker safety issue. **Advantages:** Proximity to disposal cell. **Disadvantages:** Interferes with disposal cell construction.	
Ease of delivery (8.5). Minimize the length and difficulty of the route to the storage facility and related costs. Minimize maintenance (0.0, Dropped). Minimize maintenance of storage facility and delivery road.	Army Property. drop Area south of Route A.	**Advantages:** Adequate size. Minimal impacts to on-site activities. **Disadvantages:** Land availability highly unlikely.	

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TABLE 5.1.4-1 Results of Modified Value Engineering: CMSA Site Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]		Advantages/Disadvantages	Preferred Alternative
	MDOC – North. South of State Route D and north of Weldon Spring Chemical Plant.	drop	**Advantages:** More convenient for recovery. No interference with site operations. Advantageous for worker safety issues. **Disadvantages:** More difficult to obtain – near Lake 10. Requires independent equipment for processing. Construction activity closer to Francis Howell High School. Most sensitive area. New development area.	
	MDOC – South. Triangular property on MDOC land south of abandoned road, west of State Route 94, northeast of Weldon Spring Chemical Plant Fence line, north of existing Highway Department maintenance facility.	3	**Advantages:** More convenient for recovery. No interference with site operations. Advantageous for worker safety issues. Land availability highly likely. **Disadvantages:** Requires independent equipment for processing. New development area (area requires additional site research to develop).	
	South of Raffinate Pits. South of Raffinate Pits 3 and 4.	drop	**Advantages:** Ease of recovery. **Disadvantages:** Worker safety. Question of probability of land availability. Impacts on-site activities. Inadequate size.	
	In Raffinate Pits. In Raffinate Pits 1, 2 and 3 after waste removal.	drop	**Advantages:** Adequate size. **Disadvantages:** Worker safety. Probability of land availability. Impacts on-site activities. Public perception.	

TABLE 5.1.4-1 Results of Modified Value Engineering: CMSA Site Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	(Final Rating)	Advantages/Disadvantages	Preferred Alternative
2. Location – On-site Clay Borrow				
Adequate size of storage area (12.5).	No Storage. Material placed directly in cell.	drop	**Advantages:** Simplifies operation. **Disadvantages:** Material processed in cell footprint (more activity). Congestion. Impacts to cell construction.	On-site clay borrow material will be stored and processed north of Ash Pond.
Area has adequate size to store 267,000 yd³ on-site clay borrow.	Borrow Source. An area at or adjacent to the off-site clay borrow source, southeast of Francis Howell High School.	drop	**Advantages:** Availability highly likely. Easy to construct. Minimal interference with site activities. **Disadvantages:** Negative public perception. Impacts borrow operation. Requires scanning for off-site release. Longest haul. Worker safety issues.	
Public perception (14.0). Public acceptance of storage site location including impact on Francis Howell High School local traffic patterns and environment. Worker safety (20.5). Minimize the incidence of worker exposure to accidents. Ease of recovery (7.0). Minimize the length and difficulty of the route from the storage facility to the disposal cell and related costs. Minimize impact to other activities (9.0). Locate to avoid other construction activities.	North of Ash Pond (CMSA). Area currently proposed as CMSA.	1	**Advantages:** Material stays on-site. Area is available. More convenient for recovery/delivery. Easiest to construct. Public acceptance. Worker safety. No scanning required. **Disadvantages:** Consumes valuable site space.	

TABLE 5.1.4-1 Results of Modified Value Engineering: CMSA Site Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]	Advantages/Disadvantages	Preferred Alternative
Ease of storage area construction (3.0). Minimize clear and grub, utility development, security, grading and drainage and environmental impact. Ease of land acquisition (19.0). Land can be obtained for use <u>prior</u> to and <u>during</u> disposal cell construction period. Ease of delivery (6.5). Minimize the length and difficulty of the route to the storage facility and related costs. Minimize maintenance (0.0 dropped). Minimize maintenance of storage facility and delivery road.	Marshalling Yard. drop Area adjacent to the quarry haul road at old railroad staging area south of Weldon Spring Chemical Plant.	**Advantages:** Minimum development impact. Availability likely. **Disadvantages:** Negative public acceptance. Scan for off-site release. Long haul. Impacts site activities. Difficult deliver/recovery.	
	Army Property. drop Area south of Route A.	**Advantages:** Adequate size. **Disadvantages:** Probability of land availability. Public perception. Impact other on-site activities.	
	MDOC – North. drop South of Highway D and north of Weldon Spring Chemical Plant fence line.	**Advantages:** Minimal interference with on-site activities. Short haul and recovery distance. Worker safety. **Disadvantages:** Adverse public acceptance. Land difficult to obtain. Scan for off-site release.	

TABLE 5.1.4-1 Results of Modified Value Engineering: CMSA Site Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]	Advantages/Disadvantages	Preferred Alternative
	MDOC - South. 2 Triangular property on MDOC land south of abandoned road, west of State Route Highway 94, northeast of Weldon Spring Chemical Plant fence line, north of existing Highway Department maintenance facility.	**Advantages:** Availability highly likely. Minimum interference with on-site activities. Short haul and recovery distance. Worker safety. **Disadvantages:** Negative public acceptance. Scan for off-site release.	
	In Raffinate Pits. drop In Raffinate Pits 1, 2 and 3 after waste removal.	**Advantages:** Ease of recovery/delivery. **Disadvantages:** Worker safety. Impacts other on-site activities. Public perception. Adequate size.	
3. Location - Synthetic and Natural Materials			
Adequate size of storage area (12.0).	No storage. drop Material placed directly in cell.	**Advantages:** No interference with site operations. Does not consume valuable site space. **Disadvantages:** Impacts cell construction. Reduces construction, maintenance and operational flexibility.	Synthetics and reserve natural materials will be stored north of Ash Pond.
Area has adequate size to store 12,000 yd³ synthetic & natural material.	Borrow Source. drop An area at or adjacent to the off-site clay borrow source, southeast of Francis Howell High School	**Advantages:** Land availability highly likely. No interference with site operations. **Disadvantages:** Interference with borrow operations. Difficult recovery.	

TABLE 5.1.4-1 Results of Modified Value Engineering: CMSA Site Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives (Final Rating)	Advantages/Disadvantages	Preferred Alternative
Public perception (8.5). Public acceptance of storage site location including impact on Francis Howell High School local traffic patterns and environment.	North of Ash Pond (CMSA). 1 Area currently proposed as CMSA, north of Ash Pond	**Advantages:** Space easily obtained. More convenient recovery. Easiest to construct. More secure area. **Disadvantages:** Additional site activity. Consumes valuable site space.	
Worker safety (19.5). Minimize the incidence of worker exposure to accidents. Ease of recovery (10.5). Minimize the length and difficulty of the route from the storage facility to the disposal cell and related costs. Minimize impact to other activities (12.5). Locate to avoid other construction activities. Ease of storage area construction (2.5). Minimize clear and grub, utility development, security, grading and drainage and environmental impact. Ease of land acquisition (19.6). Land can be obtained for use <u>prior</u> to and <u>during</u> disposal cell construction period. Ease of delivery (4.0). Minimize the length and difficulty of the route to the storage facility and related costs. Minimize maintenance (0.0, dropped). Minimize maintenance of storage facility and delivery road.	Marshalling Yard. drop Area adjacent to the Quarry haul road at old railroad staging area south of Weldon Spring Chemical Plant	**Advantages:** Land availability highly likely. **Disadvantages:** Interference with site operations. Most difficult to construct.	

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TABLE 5.1.4-1 Results of Modified Value Engineering: CMSA Site Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]		Advantages/Disadvantages	Preferred Alternative
	Disposal Cell Siting Area. Within the disposal cell siting area currently defined, northern portion.	drop	**Advantages:** Close proximity to cell construction. Adequate size. **Disadvantages:** Impacts cell construction.	
	Army Property. Area south of Route A.	drop	**Advantages:** Adequate size. **Disadvantages:** Impacts cell construction activities. Land availability highly unlikely.	
	MDOC – North. South of Highway D and north of Weldon Spring Chemical Plant fence line.	drop	**Advantages:** Convenient recovery. No interference with site operations. **Disadvantages:** Poor public perception. More difficult to obtain. New development area.	
	MDOC – South. Triangular property on MDOC land south of abandoned road, west of State Route 94, northeast of Weldon Spring Chemical Plant fence line, north of existing Highway Department maintenance facility.	2	**Advantages:** Convenient for recovery. No interference with site operations. Land availability highly likely. **Disadvantages:** New development area.	
	South of raffinate pits. South of Raffinate Pits 3 and 4.	drop	**Advantages:** Ease of recovery. **Disadvantages:** Inadequate size.	

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TABLE 5.1.4-1 Results of Modified Value Engineering: CMSA Site Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]	Advantages/Disadvantages	Preferred Alternative
	In Raffinate Pits. drop In Raffinate Pits 1, 2 and 3 after waste removal.	**Advantages:** Adequate size. **Disadvantages:** Not available throughout cell construction.	
	Manufacturer's site. 3 Vendor keeps inventory until ready for delivery and placement.	**Advantages:** Little or no development required. Worker safety issues. **Disadvantages:** Commodity availability/recovery. Impact on site activities. Reduce construction, maintenance, and operational flexibility.	
	Quarry haul road easement. drop Area within quarry haul road 100-foot easement.	**Advantages:** Adequate size. **Disadvantages:** Worker safety. Impact on haul activities.	
	Borrow haul road easement. drop Area within proposed borrow haul road 100-ft easement.	**Advantages:** Adequate size. **Disadvantages:** Worker safety. Impact on haul activities.	

TABLE 5.1.4-1 Results of Modified Value Engineering: CMSA Site Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	(Final Rating)	Advantages/Disadvantages	Preferred Alternative
4. Site Preparation of CMSA				
Worker safety (19.0).	Alternate 1 Provide erosion protection around perimeter of CMSA and divert runoff from CMSA to detention basins using diversion ditches. Provide straw bales to isolate known contaminated areas within the CMSA; use diversion ditches to prevent surface run-on to these areas; and use detention basins to control contaminated runoff within these areas. Clear and grub uncontaminated area first. Once general area is cleared, begin removal of contaminated soil; provide dirty haul road to haul contaminated soil to Ash Pond/spoil areas.	1	**Advantages:** Do majority of clearing first. Erosion concerns taken care of. Removing contaminated material after clean areas are cleared. Greater worker safety. **Disadvantages:** Must work around contaminated area. Increases mulch pile storage requirements.	Alternate 2 Provide erosion protection around perimeter of CMSA and divert runoff from CMSA to detention basins using diversion ditches. Provide straw bales to isolate known contaminated areas within the CMSA, use diversion ditches to prevent surface run-on to these areas, and use detention basins to control contaminated runoff within these areas. Clear and grub uncontaminated area first. Once general area is cleared, begin removal of contaminated soil; provide dirty haul road to haul contaminated soil to Ash Pond/spoils pile.

TABLE 5.1.4-1 Results of Modified Value Engineering: CMSA Site Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]	Advantages/Disadvantages	Preferred Alternative
Minimize the incident of worker exposure to accidents. Public perception (10.0). Public acceptance of site preparation of CMSA-State Route D impacts. Impacts on cell construction (10.0). Site preparation impacts on cell construction. Ease of operation (1.0, dropped). Ease of clearing area of contaminated soils. Minimize impacts on other activities (1.0, dropped). Site preparation impacts on Ash Pond spoil area storage. Impacts to CMSA operation (7.0). Site preparation impacts on CMSA operations. Utilization of CMSA area (4.0). Use CMSA area effectively.	Alternate 2 [2] Provide erosion protection around perimeter of CMSA and divert runoff to drainage basins using diversion ditches. Provide straw bales around contaminated areas and use diversion ditches to prevent surface run-on and detention basins for runoff. Provide dedicated haul road (contaminated) lined with straw bales/diversion ditches to haul soil to Ash Pond spoil area. Remove contaminated soil first. Remove straw bales that were used to outline contaminated areas. Clear and grub remaining area of CMSA. CMSA ready for clean borrow.	**Advantages:** Contaminated material is removed first. Entire area is cleared and ready for cell construction support. If CMSA requires less area, then cleaned area can be used for other site uses. **Disadvantages:** Working in wooded area. Less worker safety. Increases mulch pile.	

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TABLE 5.1.4-1 Results of Modified Value Engineering: CMSA Site Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Rating]	Advantages/Disadvantages	Preferred Alternative
	Alternate 3 Provide erosion protection around perimeter of CMSA and divert runoff to drainage basins using diversion ditches. Provide straw bales around contaminated areas and use diversion ditches to prevent surface run-on and detention basins for runoff. Provide dedicated dirty haul road and remove contaminated soil. Clear and grub remaining CMSA on an as-needed basis. (i.e., as more borrow comes in more portions of the CMSA is cleared)	3	**Advantages:** Decreases mulch pile storage requirements. **Disadvantages:** Requires lead time to clear portions of the CMSA needed for cell construction. Area not cleared cannot be used for other operations.	

TABLE 5.1.4-1 Results of Modified Value Engineering: CMSA Site Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Rating]	Advantages/Disadvantages	Preferred Alternative
5. CMSA Surfacing - Synthetic/Construction Material Yard Area and Interior Roadway Network				
Dust control (7.0). Road surface allowing the best control of dust. Maintenance (4.0). Ease of repairing roadway. Minimize CMSA demolition (0.0, dropped). Minimize cleanup of CMSA when cell construction is complete. Erosion protection (5.0). Best surface for minimizing erosion. Impacts to CMSA operations (8.0). Minimize restrictions road surfacing will put on CMSA operations. Ability to reduce CMSA size if less material is needed for cell construction. Worker safety (12.0). Maximize safety of workers. Public perception (7.0). Public acceptance of storage site location including impact on Francis Howell High School local traffic patterns and environment. Performance of surfacing (10.0). Performance of surfacing for the roadway network/material yard.	Gravel	1	**Advantages:** Repairing surface is relatively easy/extra material can be stockpiled. Material can be reused if CMSA reduces in size. Good Erosion protection. Good Dust control. Provides good foundation. **Disadvantages:** Performance not as good as concrete or asphalt but still very good.	The synthetic and natural material yard area and the interior roadways will be gravel surfaced.
	Asphalt	2	**Advantages:** Excellent erosion protection. Excellent in stockpiling and recovery. Excellent for dust control. Provides excellent foundation. **Disadvantages:** Permanent in nature; must remove if CMSA reduces in size. Repair surface requires special operation.	

TABLE 5.1.4-1 Results of Modified Value Engineering: CMSA Site Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Rating]	Advantages/Disadvantages	Preferred Alternative
	Concrete	3	**Advantages:** Excellent erosion protection. Excellent in stockpiling and recovery. Excellent for dust control. Provides excellent foundation. **Disadvantages:** Permanent in nature; must remove if CMSA reduces in size. Repair surface requires special operation.	
	Dirt	drop	**Advantages:** Does not impact CMSA operations. Provides excellent foundation. **Disadvantages:** Poor erosion protection. Poor dust control.	
	Oil/rock mix	drop	**Advantages:** Good dust control. **Disadvantages:** Public perception. Impacts CMSA operations.	
6. CMSA Surfacing – On-site Clay Borrow Staging and Stockpiling Area				
Nature of on-site clay borrow staging and stockpiling area. (Trucks will be unloading dirt and building stockpile up to 20 ft high.)	Gravel	drop	**Advantages:** Good dust control. Less maintenance. **Disadvantages:** Cannot adapt to constant change of Type 1 staging, stockpiling and processing.	The on-site clay borrow staging and stockpiling area within the CMSA will have a dirt surface and dirt roads.

TABLE 5.1.4-1 Results of Modified Value Engineering: CMSA Site Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	(Final Rating)	Advantages/Disadvantages	Preferred Alternative
	Asphalt	drop	**Advantages:** Excellent dust control. Low maintenance. **Disadvantages:** Cannot adapt to constant change of Type 1 staging, stockpiling and processing.	
	Concrete	drop	**Advantages:** Excellent dust control. Low maintenance. **Disadvantages:** Cannot adapt to constant change of Type 1 staging, stockpiling and processing.	
	Dirt	1	**Advantages:** Can accommodate road constantly changing due to storing and processing of Type 1 material. Easy maintenance. **Disadvantages:** Dust control must be done frequently. More frequent maintenance.	
	Oil/rock mix	drop	**Advantages:** Good dust control. Low maintenance. **Disadvantages:** Cannot adapt to constant change of Type 1 staging, stockpiling and processing.	

TABLE 5.1.4-1 Results of Modified Value Engineering: CMSA Site Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	(Final Rating)	Advantages/Disadvantages	Preferred Alternative
7. CMSA Erosion Protection and Surface Drainage Control				
Minimize maintenance (3.0). Minimize the need to maintain erosion control protection. Minimize impacts on CMSA operations (6.0). Minimize the need to duplicate or re-do erosion control measures while operating the CMSA. Public perception (8.0). Public acceptance of erosion protection. Worker safety (12.0). Minimize the incidence of worker exposure to accidents. Ease of placement (0.0, dropped). How easily the erosion protection can be placed or replaced.	Straw bales	2	**Advantages:** Easy installation. Easy maintenance. Easy replacement. Ample supply. Good performance. Does not impact CMSA operations. **Disadvantages:** Straw bales are normally used on drainage areas of 0.5 acres or less. Bales should be inspected frequently. Does not work well on steep slopes.	Before construction begins, provide diversion ditches/channels around boundary of the CMSA. In addition, sediment detention basins should be built at the discharge points going off site to protect off-site downstream areas from sedimentation. Diversion ditches will be lined with vegetation (Hydro-seeding). Straw bales will be used throughout construction area to divert and slow runoff as well as to trap sediment. Hydro-seeding/mulching will also be used to control erosion throughout CMSA, where needed. These features will remain in place and be maintained throughout the life of the CMSA.
Performance of erosion control (6.0). How good the different types of erosion protection are to one another.	Silt Fences	3	**Advantages:** Easy installation. Good performance. Does not impact CMSA operations. **Disadvantages:** Does not work well on steep slopes. Inspected after every storm. Drainage area should not exceed 0.5 acre per 100 foot of fence.	
	Hydroseeding/mulching/erosion control matting.	1	**Advantages:** Low maintenance. Excellent erosion protection. Works well on level and steep slopes. Does not impact CMSA operations. **Disadvantages:** Mowing.	

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TABLE 5.1.4-1 Results of Modified Value Engineering: CMSA Site Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives (Final Rating)		Advantages/Disadvantages	Preferred Alternative
	Diversion ditches/channels check dams.	4	**Advantages:** Good performance. Used on large drainage areas. Low maintenance. **Disadvantages:** Inspect after every storm.	
	Sediment detention basins.	5	**Advantages:** Good performance. **Disadvantages:** Uses substantial area. Impacts CMSA operations.	
	Riprap.	drop	**Advantages:** Good erosion control. **Disadvantages:** Need equipment to handle. More difficult to install. Overkill.	

TABLE 5.1.4-2 Observational Method: CMSA Site Preparation

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
1. Location – Off-site Clay Borrow				
Off-site clay borrow material will be stored and processed at the borrow source.	Processed material will be brought directly to the disposal cell when needed.	Material will be brought in too fast or too slowly.	Medium	Will have to step up or slow down processing at the borrow source.
	Will have adequate room to store and process material.	Will run out of room.	Very low	Will have to find another place to process material.
2. Location – On-site Clay Borrow				
On-site clay borrow material will be stored and processed north of Ash Pond (CMSA).	Clean material excavated from the disposal cell footprint will be stored at the CMSA.	Will run out of storage space in the CMSA for clean material.	Medium/High	A new area will have to be prepared for the overflow. Proposed area – Highway Department Property (MDOC - South).
		Majority of clean material can be excavated from the disposal cell footprint and can be directly placed in the clean-fill dikes.	Medium/High	CMSA can be reduced in size.
	Contaminated material will not be stored in the CMSA.	Majority of material coming out of disposal facility footprint is contaminated or gets contaminated. Need extra storage on site to place contaminated soils.	Medium/Low	Original CMSA area will be used to store contaminated soils. Contaminated soils will not be taken off site. A new area will have to be prepared for the CMSA to be off site (MDOC – South).

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TABLE 5.1.4-2 Observational Method: CMSA Site Preparation (Continued)

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
3. Location – Synthetic and Natural Materials				
Synthetics and natural material will be stored north of Ash Pond (CMSA).	Construction materials for the disposal facility will be brought in and stored at the CMSA and act as a surge facility.	Too much material brought into the CMSA.	Low	Call supplier and slow down deliveries.
		Not enough material acting as surge.	Low	Call supplier and speed up deliveries.
4. Site Preparation of CMSA				
Provide erosion protection around perimeter of CMSA and divert runoff from CMSA to detention basins using diversion ditches. Provide straw bales to isolate known contaminated areas within the CMSA, use diversion ditches to prevent surface run-on to these areas, and use detention basins to control contaminated runoff within these areas.	Erosion protection features around perimeter of CMSA expected to be maintained throughout life of CMSA. Expect contaminated material will be found in isolated locations in the CMSA site. Expect drainage of contaminated material will be contained within the contaminated area.	Erosion protection measures around perimeter will get contaminated. CMSA site is more contaminated than expected (wide spread).	Low/Medium	Cleanup of contaminated material will have to be extended to these areas and erosion protection replaced. CMSA will have to be cleared similar to the disposal cell footprint (i.e., controlled contamination runoff). Start from high point and work down gradient never letting contaminated runoff discharge on newly cleared uncontaminated area.
Clear and grub uncontaminated area first. Once general area is cleared, begin removal of contaminated soil; provide dirty haul road to haul contaminated soil to Ash Pond.			Medium	

TABLE 5.1.4-2 Observational Method: CMSA Site Preparation (Continued)

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
5. CMSA Surfacing - Synthetic and natural Material Yard Area and Interior Roadway Network				
The synthetic and natural material yard area and the interior roadways will be gravel surfaced.	Gravel surface for the synthetic and natural material yard area and interior roadway will provide a good working surface for the storage and transportation of material.	Gravel surface does not provide a good working surface for storage of materials.	Low	Use an asphalt surface for the material yard area.
		Gravel roadway is inadequate.	Very Low	Use asphalt for the interior roadway network.
6. CMSA Surfacing - On-site Clay Borrow Staging and Stockpiling Area				
The on-site clay borrow staging and stockpiling area within the CMSA will have a dirt surface and dirt roads.	On-site clay borrow will be stockpiled up to 20 ft high within the CMSA.	None	N/A	N/A

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TABLE 5.1.4-2 Observational Method: CMSA Site Preparation (Continued)

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
7. CMSA Erosion Protection and Surface Drainage Control				
Before construction begins provide diversion ditches and channels around boundary of the CMSA. In addition, sediment detention basins should be built at the discharge points going off site to protect off-site downstream areas from sedimentation. Diversion ditches will be lined consisting of vegetation (Hydro-seeding). Straw bales will be used throughout construction area to divert and slow runoff as well as trap sediment. Hydro-seeding/ mulching will also be used to control erosion throughout CMSA where needed. These features will remain in place and will be maintained throughout the life of the CMSA.	Erosion protection measures will provide adequate protection.	Erosion protection fails.	Very Low	Erosion protection will be replaced or added depending on the level of failure.

TABLE 5.1.4-3 Data Quality Objectives: CMSA Site Preparation

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
1. Location – Off-site Clay Borrow			
Material will be brought in too fast or too slowly.	Will have to step up or slow down processing at the borrow source.	What is the rate of off-site borrow coming into the site?	
Will not have enough room to store and process material.	Will have to find another place to process material.	Does the alternative borrow source have enough room to store and process Type 1 material?	Need topographic map of alternative borrow source area and layout.
2. Location – On-site Clay Borrow			
Will run out of storage space in the CMSA for clean material.	A new area will have to be prepared for the overflow. Proposed area – Highway Department property (MDOC – South).	Can we use this property? When do we study this alternative? Should we study other possible alternatives?	Need owner's permission to use property. Need topographic map and boundary of new areas being studied.
Most of clean material can be excavated from the disposal footprint and can be directly placed in the clean-fill dikes.	CMSA can be reduced in size.	Can clean material be excavated from the disposal facility footprint and placed in clean-fill dikes? How much can be anticipated?	
Most of material coming out of disposal facility footprint is contaminated or gets contaminated. Need extra storage on site to place contaminated soils.	Original CMSA area will be used to store contaminated soils. Contaminated soils will not be taken off site. A new area will have to be prepared for the CMSA to be off site (MDOC – South).	How much contaminated soil is coming from the disposal facility area? What is site capacity for storing contaminated and uncontaminated material?	Need site storage plan showing maximum storage capacities. Show sequencing of cell construction with other site activities to determine if all staging areas/stockpiling areas are adequate in size.
3. Location – Synthetic and Natural Materials			
Too much material brought into the CMSA.	Call supplier and slow down deliveries.	How many phases of cell construction will there be and what area will each phase cover?	Need construction schedule to simulate material needs.

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TABLE 5.1.4-3 Data Quality Objectives: CMSA Site Preparation (Continued)

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
4. Site Preparation of CMSA			
Erosion protection around perimeter will get contaminated.	Cleanup of contaminated material will have to be extended to these areas and erosion protection replaced.	Is there a place on site where emergency erosion protection can be stored?	Need site storage plan showing maximum storage capacities. Show sequencing of cell construction with other site activities to determine if all staging areas/stockpiling areas are adequate in size.
CMSA site is more contaminated than expected (widespread).			
5. CMSA Surfacing – Synthetic and Natural Material Yard Area and Interior Roadway Network			
Gravel surface does not provide a good working surface for storage of material.	Use an asphalt surface for the material yard area.	None	None
Gravel roadway is inadequate.	Use asphalt for the interior roadway. Network		
6. CMSA Surfacing – On-site Clay Borrow Staging and Stockpiling Area			
None	None	None	None
7. CMSA Erosion Protection and Surface Drainage Control			
Erosion protection fails.	Erosion protection will be replaced or added depending on the level of failure.		

TABLE 5.1.5-1 Results of Modified Value Engineering: Site Roads Layout

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]	Advantages/Disadvantages	Preferred Alternative
Proximity of access points to existing public roadways (9.0). Minimize length of road needed to connect entrances/exits with existing roadways. Minimize decontamination (7.0). Minimize the number of vehicles that must be decontaminated before traveling off site. Minimize cleanup demolition (3.0). Minimize the amount of roadway material to be demolished and placed in the disposal cell. Provide easy access to CMSA (11.0). Minimize the length and difficulty of the route from the CMSA to the disposal cell. Site security (6.0). Minimize the number of site entrances/exits to facilitate security. Access to off-site borrow (10.0). Provide easy access to off site borrow; facilitate travel between CMSA and off-site borrow. Separation of contaminated and clean roads (23.0). Access locations should be well removed from contaminated materials and vehicles transporting them to provide a safe and efficient site roads system.	Access at main entrance, south entrance and north entrance. 1 Provide site access from State Route 94 at the existing main entrance, from the existing quarry road to the south entrance, at the WTP entrance, and from the off-site haul road at a point on the northern boundary of the site.	**Advantages:** Main entrance near State Route 94 and south entrance already exist. Dirty roads can all be directed to decontamination pad near southern access without approaching clean exits. Employee and heavy equipment traffic entrances are separate. Easy travel between CMSA and off-site borrow; access is near off-site haul road. All access locations are near existing public roads. **Disadvantages:** Added security problems at each access location, especially with access points visible from public roads.	Designate uncontaminated clean and contaminated dirty site roads, with an off site access location at the existing main entrance, a south entrance near the existing quarry road, and a north entrance near the CMSA. Follow routes of existing site roads where possible. Construct new alignments where roads do not exist or where existing roads do not provide efficient travel between origins and destinations. Provide a continuous clean path around the site perimeter for water trucks (see MVE on dust control).

TABLE 5.1.5-1 – Results of Modified Value Engineering: Site Roads Layout (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]	Advantages/Disadvantages	Preferred Alternative
Public perception (10.0). Public acceptance of the site road system and the number and locations of access points to public roads. Separation of employee vehicles and heavy construction equipment (3.0). To avoid congestion at access locations and to improve worker safety, separate commuter and construction equipment traffic.	Access at main entrance and south entrance only. drop Provide site access at the existing main entrance, at the WTP entrance, and at the south entrance, near the existing quarry road.	**Advantages:** Main entrance and south entrance already exist. Dirty roads can be directed to decontamination pad near south entrance without approaching clean exits. Access locations are near existing roadways. **Disadvantages:** Added security problems at each access location, especially with access points visible from public roads. Complicated travel between CMSA and off-site borrow: haul trucks might use main entrance. Difficult to separate clean construction vehicles from employee vehicles. Potential congestion at main entrance (construction and employee vehicles).	
	Access at main entrance, south entrance, and northeast corner of proposed CMSA. drop Provide site access at the existing main entrance, at the south entrance near the quarry road, and at a point on the northeast corner of the proposed CMSA location. (Use State Route D to enter CMSA and other site areas.)	**Advantages:** Dirty roads can all lead to decontamination pad near south entrance without approaching clean exits. Employee and heavy equipment traffic entrances are separate. CMSA access to off-site borrow. **Disadvantages:** Added security problems at each access location, especially with access points visible from public roads. Requires new road from Highway D to site. Site activities interfere with public roadway traffic. Poor public perception.	

TABLE 5.1.5-1 – Results of Modified Value Engineering: Site Roads Layout (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]	Advantages/Disadvantages	Preferred Alternative
	Access at main entrance, south entrance and northwest corner of proposed CMSA. drop Provide site access at the existing main entrance, at the south entrance, at the WTP entrance, and at a point on the northwest corner of the proposed CMSA location. (Use State Route D to enter CMSA and other site areas).	**Advantages:** Dirty roads can all lead to decontamination pad near south entrance without approaching clean exits. Employee and heavy equipment traffic easily separated by access point. CMSA access to off-site borrow. **Disadvantages:** Added security problems at each access location, especially with access points visible from public roads. Requires new road from State Route D to site. Site activities interfere with public roadway traffic. Poor pubic perception.	
	General use of site roads. drop Allow contaminated material to be transported on all site roads (no distinction between clean and dirty roads).	**Advantages:** Minimizes material for cleanup demolition. Minimizes length of roadway to be constructed. **Disadvantages:** Presents potential hazards. Employees exposed to roads on which contaminated material is transported. Contaminated materials passing near public road access locations. Allows employees and heavy equipment to travel on the same roads. All vehicles need to be decontaminated before leaving the site; potential congestion at "southern tip" access.	

TABLE 5.1.5-2 Observational Method: Site Roads Layout

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Designate uncontaminated clean and contaminated dirty site roads, with an off-site access location at the existing main entrance, a south entrance near the existing quarry road, and a north entrance near the CMSA. Follow existing site roads where possible, using new roads where old ones do not exist or are inefficient. Provide a clean path around the entire site perimeter for clean water trucks.	Delivery trucks from off-site borrow can enter CMSA and exit through the north entry without being decontaminated. Uncontaminated construction equipment can enter and exit the site through either the north or south entrance as on the clean perimeter road proposed.	All delivery trucks entering the site must be scanned before they exit.	High	Need a decontamination pad at the north exit. An existing decontamination pad already exists at the south exit.
	Vehicles transporting personnel and/or uncontaminated material will travel only on clean roads. Other vehicles will travel only on dirty roads.	Vehicles will travel on improper roads (e.g., dirty trucks will travel on clean roads).	Very Low/None	None (See MVE on demarcation of clean/dirty roads.) Vehicles will have to exit at the South decontamination pad.
	Clean water trucks will travel around the site perimeter without crossing dirty roads.	None	–	–

TABLE 5.1.5-3 – Data Needs: Site Roads Layout

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
All delivery trucks entering the site must be scanned before they exit.	Need a decontamination pad at the north exit.	Will delivery trucks be allowed to enter and exit CMSA without being scanned?	None
Vehicles will travel on improper roads (i.e. clean trucks on dirty roads).	Vehicles will have to exit at the south decontamination pad.	None	None

TABLE 5.1.5-4 Access to Vicinity Properties

Vicinity Property Identification	Location	Primary Access Route
DAM	~500 ft from west TSA boundary.	Dirt road along west site boundary.
DA2	~1000 ft from west TSA boundary.	Dirt road along west site boundary.
DA3	~2000 ft southwest of TSA.	Dirt road southwest of site boundary.
DA4 (SDA)	Southeast Drainage segment.	Route A.
DA5	~600 ft west of Raffinate Pit 4.	Dirt road along west site boundary.
DA6	~300 ft west of CMSA.	Dirt road along west site boundary.
DOC 3	300 ft northwest of CMSA.	Dirt road along north site boundary.
DOC 4	Adjacent to Road C, ~7000 ft west of Missouri State Route 94.	Road C.
DOC 5	Adjacent to Road D, ~2500 ft east of Missouri State Route 94.	Road D.
Lake 34	~5000 ft north of Weldon Spring Chemical Plant.	Busch Wildlife entrance.
Lake 35	~4000 ft north of Weldon Spring Chemical Plant.	Busch Wildlife entrance.
Lake 36	~1000 ft north of Weldon Spring Chemical Plant.	Busch Wildlife entrance.

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TABLE 5.1.5-5 Results of Modified Value Engineering: Off-Site Borrow Haul

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]	Advantages/Disadvantages	Preferred Alternative
1. Haul Method			
Worker safety (37.5). Minimize material and equipment handling; minimize worker exposure to accidents. Public safety (32.5). Minimize impacts to public traffic and Francis Howell High School; minimize potential for accidents. Reliability (20.0). Minimize operation down time. Minimal impact to on-site activity (17.0). Minimize site congestion and its affect on cell construction.	Off-highway vehicles. 1 Off-highway trucks, scrapers, and/or other large capacity equipment would be used to haul the material along a haul road from the offsite borrow source to the site.	**Advantages:** Few vehicles would be needed (fewer haul cycles). Limits traffic congestion on site and haul route. Reduces time and labor involved in scanning and decontamination. Requires less labor to operate than a large fleet of smaller vehicles. System is very reliable and flexible. Point-to-point delivery. Total life cycle cost is low (approximately $3.9 million). **Disadvantages:** Small business are not likely to own large capacity off-highway vehicles. Requires a wider haul road with a thicker pavement section than road for highway vehicles. Mud and dust must be controlled throughout hauling activity.	Allow contractors to bid using either haul units (highway or off-highway) or conveyor system. See details of preferred alternative in text.

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TABLE 5.1.5-5 Results of Modified Value Engineering: Off-Site Borrow Haul (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]	Advantages/Disadvantages	Preferred Alternative
Low operation and maintenance costs (16.5). Minimize haul route operation and maintenance costs in terms of haul distance, haul cycles, equipment, and labor. Simple permitting process (15.5). Ease of receiving permits from owners and concerned agencies. Minimal scanning and decontamination (14.5). Minimize time and labor required to scan and decontaminate equipment. Minimize effect of scanning and decontamination on haul cycle. Mud and dust control (11.5). Limit spilling of material along haul route; minimize impacts to environment and Highway 94. Land availability (10). Land must be available for haul route. Low initial cost (8.0). Site security (7.0). Prevent public access to the site and protect haul system equipment. Flexibility of operation (6.5). Mobility of equipment and potential for use in other remediation activities Public perception (6.5). Use a haul method that is accepted by the public; minimize noise. Minimize restoration effort (0.0, dropped). Reusability of equipment. Minimize cost and labor to abandon operation.	Conveyor system. 2 The conveyor would be loaded at the off-site borrow area and unloaded at the site.	**Advantages:** Requires the minimum labor, scanning, and decontamination to operate. Small and contained; best system for dust control. Requires minimal restoration effort at completion of operation. Low noise, small size; best public perception. Can cross steep grades; shortest haul route. **Disadvantages:** Requires hauling to and from the conveyor. Has not been used before at a remediation site. The system is not at all flexible. No backup; if the system fails, hauling ceases completely. High life cycle cost (approximately $5.0 million).	

TABLE 5.1.5-5 Results of Modified Value Engineering: Off-Site Borrow Haul (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]	Advantages/Disadvantages	Preferred Alternative
	Highway vehicles on haul road. 3 Highway trucks, with a lower capacity than off-highway vehicles, would be used to haul material along a haul road from the off-site borrow to the site.	**Advantages:** Great flexibility; highway vehicles can be driven to other locations for use in other operations. Haul road would be smaller and have a thinner pavement section than a road for off-highway vehicles. Point-to-point delivery. Total life cycle cost is relatively low (approximately $4.3 million). Can be provided by small businesses. **Disadvantages:** High number of vehicles (many haul cycles) required to deliver material. Increased congestion on site and haul route. Increased labor to operate system. Higher number of workers (drivers) increases probability of worker accidents.	
	Highway vehicles on public roadways. 4 Highway vehicles would haul material on existing public highways (State Route 94).	**Advantages:** Great flexibility. No haul road must be constructed; operation could start immediately. Point-to-point delivery. Can be provided by small businesses. **Disadvantages:** Interaction with local traffic; public safety is a concern. Poor public perception. More vehicles needed than for highway vehicles on haul road (longer haul cycle). Mud and dust control a greater concern, because public roads are used. Highest life cycle cost (approximately $5.8 million).	

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TABLE 5.1.5-6 Results of Modified Value Engineering: Off-Site Borrow Haul State Route 94 Crossing

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]	Advantages/Disadvantages	Preferred Alternative
Minimize initial cost (1.0). Public safety (7.5). Protect drivers on State Route 94. Worker safety (7.0). Protect haul system operators and workers who maintain the haul route. Public perception (1.0). Crossing appearance and incidental disturbance of State Route 94 traffic. Simple permitting process (3.0). Simplify process of obtaining permits to construct crossing.	Below grade haul unit crossing. 1 A below grade truck crossing would be a single lane for off-highway vehicles, or a double lane crossing of the same width for highway vehicles. A signalized or controlled single lane crossing is manageable for off-highway vehicles because of the smaller number of haul cycles.	**Advantages:** Public would not see vehicles crossing the highway; good public perception. Better public safety than above grade crossing. Does not affect haul route alignment (crossing can be almost anywhere). Workers maintaining crossing do not risk falling onto State Route 94. **Disadvantages:** Potential drainage problems in tunnel. Potential problems with underground utilities. High cost of large tunnel construction.	Use a below ground truck or conveyor crossing, depending upon the haul method used.
NOTE: Low-scoring criteria were kept due to the small number of criteria.	Below grade conveyor crossing. 2 A below ground conveyor crossing would include a 12-ft wide single lane maintenance road.	**Advantages:** Public is not affected; good public safety and public perception. Does not affect haul route alignment. Crossing would be smaller and less costly than truck crossing. **Disadvantages:** Potential drainage problems in tunnel. Potential problems with underground utilities. High cost of tunnel construction.	

TABLE 5.1.5-6 Results of Modified Value Engineering: Off-Site Borrow Haul State Route 94 Crossing (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]		Advantages/Disadvantages	Preferred Alternative
	Above grade truck or conveyor crossing.	3 (tie)	**Advantages:** Minimizes utility relocation; less interaction with subsurface. Smaller, less costly structures. Easier to construct. **Disadvantages:** Poor public perception. Could pose a public safety hazard, due to possibility of material falling onto State Route 94. Alignment is critical; crossing cannot be anywhere, due to sight distance requirements on State Route 94.	

TABLE 5.1.5-7 Observational Method: Off-Site Borrow Haul

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
1. Haul Method				
Subcontractors bid using either haul units or conveyor system. Possible haul route alignments are as shown in Figures 5.1.5-11 and 5.1.5-12.	Borrow material will be processed at borrow source.	Borrow source lacks space to process material.	Very low	Search for area to process material; site space is limited.
	Land is available to construct new haul route.	Land owners do not permit new haul route construction.	Low	Haul material using highway vehicles on State Route 94.
	Suggested haul routes do not disturb historically significant land.	Recommended haul routes disturb historically significant land.	Low to medium	Devise plan to remove and preserve artifacts or use different haul route alignment.
	Topographic data is accurate for suggested haul route alignments.	Topographic data used to generate alignments is inaccurate.	Medium	Obtain accurate survey data; determine if suggested haul routes must change.
	Soils can support either conveyor route or haul road.	Haul road construction is impracticable due to weak soils.	Very low	Contractors bid using conveyor systems.
	Haul route construction will not interfere with existing utilities.	Haul route encounters existing utilities.	Very high	Relocate utilities.
2. Highway 94 Crossing				
State Route 94 crossing will be an underground truck or conveyor crossing.	Missouri Highway and Transportation Department approves suggested conveyor and truck crossing locations.	MHTD does not concur with State Route 94 crossing plans.	Very low (underground crossing should be acceptable).	Work with MHTD to devise new plan for State Route 94 crossing. Haul units must drive on State Route 94 if they cannot cross it.
	MHTD designs truck crossing.	MHTD concurs with crossing location plans, but does not design truck crossing.	Medium	Design haul unit crossing.

TABLE 5.1.5-8 Data Quality Objectives: Off-Site Borrow Haul

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
1. Haul Method			
Borrow source lacks space to process material.	Search for area to process material; site space is limited.	Will borrow material be processed at the borrow source?	Layout of borrow source, borrow material soils information and processing requirements.
Land owners do not permit new haul route construction.	Haul material using highway vehicles on State Route 94.	Who owns the land between the borrow source and the site. From whom/what agency(ies) must permits be obtained?	Land ownership map.
Recommended haul routes disturb historically significant land.	Devise plan to remove and preserve artifacts or use different haul route alignment.	Will the suggested haul route alignments disturb historically significant land?	Archeological survey of area between borrow source and site.
Topographic data used to generate alignments is inaccurate.	Obtain accurate survey data; determine if suggested haul routes must change.	Are the suggested haul route alignments acceptable for the existing terrain?	Topographic survey.
Haul road construction is impracticable due to weak soils.	Contractors bid using conveyor systems.	What is the bearing capacity of the soils between the haul route and the site? Can a reasonable pavement section be designed to support the heavy vehicle loads?	Soils information/geotechnical data for suggested haul route alignments.
Haul route encounters existing utilities.	Relocate utilities.	What existing utilities will the suggested haul routes encounter?	Existing utility map.
2. Highway 94 Crossing			
MHTD does not concur with State Route 94 crossing plans.	Work with MHTD to devise new plan for State Route 94 crossing. Haul units must drive on State Route 94 if they cannot cross it.	Will MHTD concur with State Route 94 crossing design.	MHTD concurrence.

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TABLE 5.1.5-8 Data Quality Objectives: Off-Site Borrow Haul (Continued)

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
MHTD concurs with crossing location plans, but does not design truck crossing.	Design haul unit crossing.	Will MHTD design State Route 94 truck undercrossing?	MHTD concurrence.

TABLE 5.1.5-9 Results of Modified Value Engineering: Site Roads Layout Design Criteria

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Rating]	Advantages/Disadvantages	Preferred Alternative
1. Maximum Grade and Vertical Curve Requirements				
Minimize tractive effort (6.0). Minimize addition to tractive effort of hauling equipment on slopes. Minimize cleanup demolition (8.0). Minimize the amount of material used to construct site roads. Minimize maintenance (1.0, dropped). Minimize wear and tear of surface on slopes. Ease of construction (5.0). Minimize work required to construct site roads. Cut and fill balancing (7.0). Minimize cut and fill required to flatten slopes.	Grade guidelines: Maximum grade 6%	1	**Advantages:** Low cut and fill required to construct roads over many areas of the relatively flat site. Vehicles can reach reasonable speeds without being encouraged to go too fast. Acceptable additional tractive effort. **Disadvantages:** None.	Maximum allowable grade on site roads is 6%. The maximum allowable change in grade on site roads is 5%, if a vertical curve is not constructed.
	Maximum grade 7%.	2	**Advantages:** Less cut and fill to meet requirement on the relatively flat site. **Disadvantages:** Steeper grades forces lower speeds on site roads. Less productive time.	
	Maximum grade 5%.	3	**Advantages:** Good ride quality. Low tractive effort. Vehicles can attain higher speeds on site roads, potentially speeding up construction work. **Disadvantages:** More cut and fill needed to flatten roads to meet requirement. Additional fill adds to disposal cell content. Drivers could be encouraged to travel too fast on flat roads.	

TABLE 5.1.5-9 Results of Modified Value Engineering: Site Roads Layout Design Criteria (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	(Final Rating)	Advantages/Disadvantages	Preferred Alternative
	Maximum grade 4%.	drop	**Advantages:** Low tractive effort (1600 added pounds for a 20-ton vehicle). Vehicles can attain higher speeds on site roads, potentially speeding up construction work. **Disadvantages:** More cut and fill needed to flatten roads to meet requirement.. Additional fill adds to disposal cell content. Drivers could be encouraged to travel too fast on flat roads.	
	Vertical curve requirements: A vertical curve is required if the tangent-grade change exceeds 5%.	1	**Advantages:** Requirement easy to meet on flat site. Vehicles achieve moderate speeds on site roads. Maximum acceptable site distances for haul roads. **Disadvantages:** Site distances decrease.	
	A vertical curve is required if the tangent-grade change exceeds 6%.	2	**Advantages:** Requirement is not difficult to meet on relatively flat site. **Disadvantages:** Slightly uncomfortable ride on grade changes that form a "sag." Not acceptable site distance.	
	A vertical curve is required if the tangent-grade change exceeds 4%.	drop	**Advantages:** Requirement easy to meet on flat site. **Disadvantages:** Not much benefit over a 5% grade change. Drivers could be encouraged to travel too fast.	

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TABLE 5.1.5-9 Results of Modified Value Engineering: Site Roads Layout Design Criteria (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Rating]	Advantages/Disadvantages	Preferred Alternative
2. Horizontal Curves				
Vehicle slow-down (0.5). Vehicles should not have to slow down too much to avoid running off the road at a tangent. Ease of construction (2.0). Simplify horizontal alignment as much as possible. Minimize cleanup demolition (4.0). Minimize amount of material to be added to disposal cell by minimizing the total length of roadway. NOTE: Low-scoring criteria were kept due to the small number of criteria that affect selection of curve radius.	Minimum Inside Radius of 100 ft. The inside radius is the distance from the edge of the inside lane to the center of the curve. An 100-ft minimum radius allows vehicles to travel about 25 mph on curves.	1	**Advantage:** Safe for vehicles travelling over the posted speed limit. **Disadvantage:** May be constrained by construction activity in some areas. More material for clean-up demolition.	Minimum inside radius of horizontal curves is 100 ft.
	Minimum Inside Radius of 80 ft. An 80-ft minimum radius allows vehicles to travel about 20 mph on curves.	2	**Advantage:** Safe for vehicles travelling at posted speed limit. **Disadvantages:** May be constrained by construction activity in some areas. Vehicles sometimes exceed the speed limit – could be hazardous.	
	Minimum Inside Radius of 35 ft. Vehicles can travel 14-16 mph on curves.	3	**Advantages:** Vehicles can travel at the expected average speed on site roads. **Disadvantages:** Vehicles sometimes exceed the speed limit – could be hazardous.	

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TABLE 5.1.5-9 Results of Modified Value Engineering: Site Roads Layout Design Criteria (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]		Advantages/Disadvantages	Preferred Alternative
3. Lane and Shoulder Widths - One-way Single Lane Roads for Highway Vehicles				
Safety (23.0). Lane widths must accommodate the widest vehicle. Reasonable traffic flow (10.0). Construction vehicles should be able to travel on site roads at a reasonable rate. Ease of construction (3.0). Minimize time, materials, and labor required to construct site roads. Minimize maintenance (1.0, dropped). Minimize cleanup demolition (7.0). Minimize amount of material to be added to disposal cell. Public perception (11.0). How the public perceives the safety and appearance of the site roads. Drainage (6.0). It is assumed that side slopes will be steeper than roadbed slopes, so that a wider roadbed ("flat" area, with poor drainage) discourages drainage off the road. Cut and fill balancing (5.0). Minimize cut and fill required to construct road section.	12-ft Lane with 0 ft to 2-ft shoulders.	1	**Advantages:** Safe, good traffic flow. Low amount of material for cleanup demolition. Good drainage. **Disadvantages:** Little extra room on roadway in case of emergency; may need to provide some turnouts.	One-way single lane road beds will be 12 ft wide with 0 to 2-ft shoulders.
	14-ft lane with 0 ft to 2-ft shoulders.	2	**Advantages:** Safe, roomy lanes for good traffic flow. **Disadvantages:** Added material for cleanup demolition. Not much benefit over 12-ft lane.	
	12-foot Lane with 0 ft to 4-ft shoulders.	3	**Advantages:** Safe, good traffic flow. **Disadvantages:** Added material for cleanup demolition. Not much benefit over section with 0 ft to 2-ft shoulders.	
	15-ft lane with 0 ft to 2-ft shoulders.	drop	**Advantages:** Safe, roomy lanes for very good traffic flow. Possible better public perception than narrow lane. **Disadvantages:** Added material for cleanup demolition. Poor drainage on wide, flat surface. Extra wide lanes are not necessary.	

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TABLE 5.1.5-9 Results of Modified Value Engineering: Site Roads Layout Design Criteria (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Rating]	Advantages/Disadvantages	Preferred Alternative
	15-ft lane with 0 ft to 4-ft shoulders.	drop	**Advantages:** Same as for 15-ft lane, 0 ft to 2-ft shoulders. **Disadvantage:** Unnecessary added width.	
	14-ft lane with 0 ft to 4-ft shoulders.	drop	**Advantages:** Safe, roomy lanes for very good traffic flow. Possible better public perception than narrower lane. **Disadvantages:** Added material for cleanup demolition. Poor drainage on wide, flat surface. Extra shoulder width lanes not necessary.	
4. Lane and Shoulder Widths - Two-way Double Lane Roads for Highway Vehicles				
	24-ft roadbed with 0 ft to 4 ft shoulders.	1	**Advantages:** Safe, good traffic flow in both directions. Extra room on shoulders; probably no need for turnouts. Similar to one-way single-lane roadbed, for consistency. **Disadvantages:** More material than for 0 ft to 2-ft shoulders.	Two-way double lane roadbeds will be 24-ft wide with 2 ft to 4-ft shoulders.

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TABLE 5.1.5-9 Results of Modified Value Engineering: Site Roads Layout Design Criteria (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]		Advantages/Disadvantages	Preferred Alternative
	24-ft roadbed with 0 ft to 2-ft shoulders	2	**Advantages:** Safe, good traffic flow. Small amount of material for cleanup demolition. **Disadvantages:** If one vehicle has a problem, a vehicle traveling in the opposite direction could need a few extra feet on the shoulder.	
	28-ft roadbed with 0 ft to 2-ft shoulders.	3	**Advantages:** Roomier lanes for large vehicles. **Disadvantages:** Poor drainage. More material for cleanup demolition. Extra room not needed.	
	Lane widths greater than 28-ft, or 28-ft lanes with 0 ft to 4-ft shoulders.	drop	**Advantage:** Plenty of room for avoiding accidents. **Disadvantages:** Too much room - unnecessary. Added material to disposal cell.	

TABLE 5.1.5-10 Observational Method: Site Roads Layout Design Criteria

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
1. Maximum Grade and Vertical Curve Requirements				
Maximum allowable grade on site roads is 6%.	No grades will exceed 6%.	Short stretches of road may need to have grades that exceed 6%.	Medium	Allow grades up to 10% for reasonably short distances.
Maximum allowable tangent-grade change is 5%, if a vertical curve is not constructed.	A vertical curve will be used for all tangent-grade changes exceeding 5%.	Some areas may present a hazard to workers if grade change is as high as 5%.	Very Low	A vertical curve is required if the tangent-grade change exceeds 1%.
2. Horizontal Curves				
Minimum inside radius of horizontal curves is 100 ft.	All inside curve radii will be at least 100 ft.	Special constraints require a smaller inside radius in some areas.	Low to Medium	Provide means of reducing speed (e.g., stop signs) before vehicles reach these curves.
3. Lane and Shoulder Widths - One-way Single-Lane Roads				
One-way single lane roadbeds for highway vehicles will be 12 ft wide with 0 ft to 2-ft shoulders. One-way roadbeds for off-highway vehicles with 2-ft shoulders.	One-lane roads will accommodate only one-way traffic.	Low volumes of traffic may allow two-way traffic.	Low to Medium	Provide turnouts on one-lane roads to allow two-way traffic where one-way traffic volumes are low.
4. Lane and Shoulder Widths - Two-way Double-lane Roads				
Two-way double-lane roadbeds for highway vehicles will be 24 ft wide with 2 ft to 4 ft shoulders. Two-way road beds for off-highway will be 32 ft wide with 4-ft shoulders.	Two lanes will be used for roads with two-way traffic.	Low volumes of traffic on two-way roads.	Low to Medium	Two-way roads may be reduced to one-way roads where applicable.

TABLE 5.1.5-11 Data Quality Objectives: Site Roads Layout Design Criteria

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
1. Maximum Grade and Vertical Curve Requirements			
Short stretches of road may require grades that exceed 8%.	Allow grades up to 10% for reasonably short distances.	None	None
Some areas may present a hazard to workers if grade change is as high as 5%.	A vertical curve is required if the tangent-grade change exceeds 1% in treacherous areas.	How many shifts will there be for cell construction (swing or graveyard shifts)?	None
2. Horizontal Curves			
Spatial constraints confine the inside radius of horizontal curves to less than 100 ft.	Provide means of reducing speed (e.g., stop signs) before vehicles reach these curves.	None	None
3. Lane and Shoulder Widths - One-way Single-lane Roads			
Low volumes of traffic may allow two-way traffic.	Provide turnouts on one-lane roads to allow two-way traffic where one-way traffic volumes are low.	None	Expected traffic volumes on one-way site roads.
4. Lane and Shoulder Widths - Two-way Double-lane Roads			
Low volumes of traffic on two-way roads.	Two-way roads may be reduced to one-way roads where applicable.	None	Expected traffic volumes on two-way site roads.

TABLE 5.1.5-12 Results of Modified Value Engineering: Site Roadway Preparation

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Rating]	Advantages/Disadvantages	Preferred Alternative
1. Roadbed Cross-Slopes - One-way Single Lane Roads				
Ease of steering (7.0). Steep cross-slopes or crown slopes can make steering difficult. Ease of construction (1.0). Minimize labor and materials required to construct roadbeds. Minimize cleanup demolition (6.0). Minimize amount of material on site roads to add as little as possible to disposal cell. Cut and fill balancing (1.0). Drainage (6.0). Provide for adequate drainage of roadbeds. Road safety and public perception (9.0). The safety of the site roads and public acceptance.	Crown slope 2%-6%.	1	**Advantages:** Small quantity of material required to build crown slope. Good steering. Good drainage. **Disadvantages:** More complicated to construct than cross slope.	One-way single-lane site roads will have a crown slope of minimum 2% and maximum 6%.
	Cross-slope 2%-6%, sloping toward the site on perimeter roads.	2	**Advantages:** Easy to construct. Good drainage: can slope road bed to meet drainage ditches. Perhaps good public perception, because perimeter roads may appear to contain contaminated water on site. Does not affect steering. **Disadvantages:** Sloping over entire road bed builds up more material for clean-up demolition. Driver may experience steering problems.	
	Minimum 2% cross-slope, sloping toward site on perimeter roads.	drop	**Advantages:** Easy to construct. Good drainage; good control of stormwater run-on and runoff. Good public perception. **Disadvantages:** Drivers may experience steering difficulties with slopes greater than 6%. Builds up more material than crown slope alternative.	

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TABLE 5.1.5-12 Results of Modified Value Engineering: Site Roadway Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Rating]	Advantages/Disadvantages	Preferred Alternative
	Maximum 6% crown slope Crown slopes less than 2% are allowed.	drop	**Advantages:** Easy steering. Small amount of material for cleanup demolition. **Disadvantages:** Can get very flat roadbeds; poor drainage.	
2. Roadbed Cross-slopes - Two-way Double Lane Roads				
	One 2%-6% crown slope across roadbed.	1	**Advantages:** Does not affect steering. Good drainage. **Disadvantages:** Drivers may perceive steering problems. Slight buildup of material in center of roadbed; more to demolish.	Two-way double-lane site roads will have a crown slope of minimum 2% and maximum 6%.
	One 2%-6% cross-slope, sloping towards site on perimeter roads.	2	**Advantages:** Good appearance to public; seems to contain water on site. Good drainage for water on roads. **Disadvantages:** Large buildup of material on outer edge of roadbed. Steering may appear difficult to drivers.	

TABLE 5.1.5-12 Results of Modified Value Engineering: Site Roadway Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]	Advantages/Disadvantages	Preferred Alternative
	Two minimum 2% crown slopes. Construct one crown slope per lane, with slopes above 6% allowed. drop	**Advantages:** Better drainage than two 2%-6% crown slopes. **Disadvantages:** Complicated construction. Requires special consideration of drainage; ditches formed in center of roadbeds will need outlets. More buildup of material for demolition.	
	Two 2%-6% crown slopes. Construct one crown slope per lane. drop	**Advantages:** Easy steering. Same as preferred section for two lanes as for one-way single-lane. Low buildup of material to be demolished. **Disadvantages:** Complicated construction. Requires special consideration of drainage; ditches formed in center of roadbeds will need outlets.	
	One 6% maximum crown slope. Crown slopes less than 2% allowed. drop	**Advantages:** Good steering. Low buildup of material for demolition. **Disadvantages:** Can get flat slopes with inadequate drainage of roads.	

TABLE 5.1.5-12 Results of Modified Value Engineering: Site Roadway Preparation (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]		Advantages/Disadvantages	Preferred Alternative
3. Side Slopes				
Maintainability (5.0). Slopes should be mild enough to drive mowers on them. Ease of construction (0.0, dropped). Time and materials needed to construct side slopes. Minimize cleanup demolition (6.0). Minimize amount of material needed to build required height of side slopes. Cut and fill balancing (4.0). Drainage (6.0). Provide a means of quick drainage away from roads. Slope stability and public/worker safety (11.0). Provide a stable slope in conjunction with public/worker safety	Maximum side slopes 3:1.	1	**Advantages:** Easily mowed. Not difficult to construct. Good drainage. **Disadvantages:** For a given height of side slope, requires more material and labor than steeper slope.	Site roads side slopes will be maximum 3H:1V.
	Maximum side slopes 2:1.	2	**Advantages:** Good drainage. Easy to construct. **Disadvantages:** Difficulty in mowing.	
	Maximum side slopes 1:1.	drop]	**Advantages:** Small amount of material to meet required height of side slopes. Very good drainage. **Disadvantages:** very difficult to mow.	

TABLE 5.1.5-13 Observational Method: Site Roadway Preparation

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
1. Roadbed Cross-slopes - One-way Single-lane Roads				
One-way single-lane site roads will have a crown slope of minimum 2% and maximum 6%.	All one-way roads will have a crown slope 2%-6%.	Due to drainage requirements, runoff may need to be directed to one side of the roadway.	Medium	Use a 2%-6% cross-slope, sloping to the side specified by drainage requirements.
2. Roadbed Cross-slopes - Two-way Double-lane Roads				
Two-way double-lane roadbeds will be 24 ft wide with 2 ft 4 ft shoulders.	All two-way roads will have a crown slope 2%-6%.	Due to drainage requirements, runoff may need to be directed to one side of the roadway.	Medium	Use a 2%-6% cross-slope, sloping to the side specified by drainage requirements.
3. Side Slopes				
Site roads side slopes will be maximum 3H:1V.	All site roads side slopes will be 3:1.	Special constraints prevent building 3:1 side slopes.	Medium	Allow maximum 2.5:1 side slopes where site constraints make 3:1 slopes very difficult or impracticable.

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TABLE 5.1.5-14 Data Quality Objectives: Site Roadway Preparation

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
1. Roadbed Cross-slopes - One-way Single-lane Roads			
Due to drainage requirements, runoff may need to be directed to one side of the roadway.	Use a 2%-6% cross-slope, sloping to the side specified by drainage requirements.	Coordination with Site Drainage Plan, so that roads slope to drain in specified directions.	None
2. Roadbed Cross-slopes - Two-way Double-lane Roads			
Due to drainage requirements, runoff may need to be directed to one side of the roadway.	Use a 2%-6% cross-slope, sloping to the side specified by drainage requirements.	Locations where site roads must drain to one side – Site Drainage Plan	None
3. Side Slopes			
Spatial constraints prevent building 3:1 side slopes.	Allow maximum 2.5:1 side slopes where site constraints make 3:1 slopes very difficult or impractical.	None	None

TABLE 5.1.5-15 Results of Modified Value Engineering: Surfacing

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]	Advantages/Disadvantages	Preferred Alternative
1. Surface Material			
Dust control (11.0). No dust is allowed to migrate off site roads. Minimize maintenance (2.0). Minimize daily or minor maintenance required to keep site roads in operation. Minimize cleanup demolition (5.0). After use of site roads, material will be demolished and placed in disposal cell. Public perception (11.5). Appearance of road surface; public perception of surface performance. Ease of construction (2.0). Minimize time, materials, and equipment required to construct surface layer. Worker safety (16.0). Surface should be stable throughout design life. Performance of surface (4.0). Strength, stability, and durability of the surface. Impacts on cell construction (10.0). Construction of site roads must not interfere with cell construction or any other project activities.	Gravel 1	**Advantages:** Good dust control. Ease of construction. Low daily maintenance. Good performance; minor maintenance required (patching, etc.). Minimal material added to disposal cell. **Disadvantages:** More use of water trucks to control dust (see results of dust control MVE).	All roads within the project boundary will have gravel surfaces.
	Oil/rock drop Gravel compacted with petroleum-based binder (chip seal).	**Advantages:** Very good dust control; less use of water trucks. Low maintenance. Good performance. **Disadvantages:** Additional equipment and materials needed to construct. May need major patchwork periodically - could be broken by heavy trucks. Additional contaminants (road oil) on site.	
	Asphalt concrete drop	**Advantages:** Excellent dust control. Very low maintenance. Good performance. Good public perception (appearance). **Disadvantages:** Special equipment required. More time needed to construct; may impact cell construction. More material to be demolished and added to disposal cell. Additional contaminants (asphalt cement) on site.	

TABLE 5.1.5-15 Results of Modified Value Engineering: Surfacing (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]	Advantages/Disadvantages	Preferred Alternative
	Portland cement concrete — drop	**Advantages:** Excellent dust control. Very low maintenance. Very good performance. **Disadvantages:** Lack of flexibility. Permanent characteristics. Special equipment required to construct. Curing time may affect cell construction. Added difficulty to cleanup demolition.	
2. Compaction and Thickness of Gravel Roads			
Ease of construction (2.0). Required degree of compaction should not be too difficult to attain. Minimize cleanup demolition (1.0). Lower stiffness (less compaction) requires a higher thickness of material to support the same loads, leaving more material for cleanup demolition. Minimize maintenance (0.0, dropped). Good compaction improves stability, strength and durability of surface.	70% relative density; 6 in. to 10-in. thickness. — 1 Compact to 70% of the gravel's relative density. Use a 6 in. to 10-in. gravel section.	**Advantages:** 70% relative density (94% relative compaction) is attainable. Relatively thin surface so few lifts must be used in compaction. Results in strong, durable surface. **Disadvantages:** 70% relative density is not easy to achieve. Smaller thickness needed for a higher level of compaction.	Compact gravel roads to 95% of the modified proctor maximum dry density. Use a 6 in. to 10-in. surface thickness.
	100% relative density; 4 in. to 6-in. thickness. — drop Compact gravel to of the gravel's relative density. Use a 4 in. to 6-in. gravel thickness.	**Advantages:** High degree of compaction requires low surface thickness to support load; minimizes material to be demolished. Strong, stiff, durable surface. **Disadvantage:** 100% relative density is very difficult to achieve (not worth the effort).	

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TABLE 5.1.5-16 Summary of Pavement Material Thicknesses

Material		CBR	Thickness for H-20 Loading (in.)			Thickness for 40-ton Loading (in.)			Thickness for 58-ton Loading (in.)		
			ACC	PCC	ASC	ACC	PCC	ASC	ACC	PCC	ASC
Assume Subgrade CBR = 3											
Surface Course	AC	n/a	2			4			4		
	PCC	n/a		2			2			4	
	Ag. Surface Course	n/a			6			8			10
AB		30	20	20	16	45	47	41	59	59	53
Total Section			22			49			63		
Assume Subgrade CBR = 7											
Surface Course	AC	n/a	2			4			4		
	PCC	n/a		2			2			4	
	Ag. Surface Source	n/a			6			8			10
AB		30	11	11	7	25	27	21	31	31	25
Total Section			13			29			35		

TABLE 5.1.5-17 Observational Method: Surfacing

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
1. Surface Material				
All roads within the project boundary will have gravel surfaces.	All site roads will be gravel.	Gravel does not provide an adequate working surface for site roads.	Very Low	Use an asphalt surface to provide the necessary performance level.
2. Compaction and Thickness of Gravel Roads				
Compact gravel roads to 70% of relative density. Use a 6-in. -10 in. surface thickness.	All gravel roads will be 6 in.-10 in. thick, compacted to 70% relative density. Periodic minor maintenance of site roads will be necessary.	Road surface does not perform as well as expected.	Low	Thicken gravel section and recompact to improve surface performance.

TABLE 5.1.5-18 Data Quality Objectives: Surfacing

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
1. Surfacing			
Gravel does not provide an adequate working surface for site roads.	Use an asphalt surface to provide the necessary performance level.	None	None
2. Compaction and Thickness of Gravel Roads			
Road surface does not perform as well as expected (excessive maintenance required).	Thicken gravel section and recompact to improve surface performance.	Doe existing site roads exhibit excessive rutting/require extensive maintenance?	Locations of roads with rutting problems, potential causes.

TABLE 5.1.5-19 Site Roads Design Criteria Guidelines

Parameter	Criteria	Justification
Horizontal Curves	Minimum inside radius 100 ft, lower radii permitted with a means of slowing down vehicles before turns.	Moderate speed maintained on curves, low amount of material for cleanup demolition.
Roadbed Width	One-way single-lane roads for highway traffic: 12 ft. Two-way double-lane roads for highway traffic: 24 ft. One-way single-lane roads for off-highway vehicles: 16 ft. Two-way double-lane roads for off-highway vehicles: 32 ft. Two-way traffic allowed on single-lane roads with turnouts.	Safe, efficient travel, low material for cleanup demolition, good drainage; two-way traffic on single-lane roads where traffic volumes are low.
Shoulder Width	One-way single-lane roads for highway traffic: 0 ft to 2 ft. Two-way double-lane roads for highway traffic: 0 ft to 4 ft. One-way single-lane roads for off-highway vehicles: 0 ft to 2 ft. Two-way single-lane roads for off-highway vehicles: 0 ft to 4 ft.	Safe, efficient travel, good drainage, low material for clean-up demolition.
Grades	Maximum 6%; maximum 10% allowed for short distances where space is limited.	Good ride quality at moderate speeds, improved production rates.
Vertical Curves	Required where tangent-grade change exceeds 5%, or where grade change exceeds 1% in treacherous areas.	Good ride quality at moderate speeds, improved production rates, worker safety in hazardous areas.
Cross slopes	2%-6% crown slope; 2-6% cross slope where required for drainage.	Good steering, good drainage, low material for clean-up demolition.
Side Slopes	3:1 max.; 2.5:1 max where space is limited.	Ease of mowing, good drainage, low material for cleanup demolition.
Surface	Gravel – thickness of surface and base courses depend on loading.	Good dust control, low material for cleanup demolition, very good public perception, ease of construction, low impact to cell construction.
Compaction of Gravel Surface	95% of maximum dry density as determined by standard Proctor (ASTM 698).	Good stability, durability and strength, low surface thickness for cleanup demolition.

TABLE 5.1.5-20 Outline of Specifications

1 - GENERAL CONDITIONS
1.1 Definition of Terms
1.2 Scope of Work
1.3 Control of Work
1.4 Control of Material
1.5 Legal Regulations and Responsibility to the Public
1.6 Prosecution and Progress
1.7 Measurement and Payment

2 - EARTHWORK
2.1 Clearing and Grubbing
2.2 Removals
2.3 Roadway and Drainage Excavation, Embankment, and Compaction
2.4 Embankment Control
2.5 Overhaul
2.6 Linear Grading
2.7 Subgrade Preparation
2.8 Subgrade Compaction
2.9 Subgrade Scarifying
2.10 Subgrading and Shouldering
2.11 Shaping Shoulders
2.12 Water
2.13 Shaping Slopes
2.14 Grading, Shaping, and Compacting

3 - BASES AND AGGREGATE SURFACES
3.1 Aggregate Base Course
3.2 Aggregate Surface
3.3 Processing Aggregate Surface

4 - MATERIALS DETAILS
4.1 General Requirements for Materials
4.2 Aggregate Surfacing Material
4.3 Aggregate Base Material
4.4 Water

5 - INCIDENTAL CONSTRUCTION
5.1 Markers and Monuments
5.2 Guard Rail, Guard Cable, and Guard Fence
5.3 Barricades and Construction Signs

6 - ROADSIDE DEVELOPMENT
6.1 Fertilizing
6.2 Mulching
6.3 Sodding
6.4 Topsoil
6.5 Seeding
6.6 Netting
6.7 Planting Trees, Shrubs, and Other Plants

7 - TRAFFIC CONTROL FACILITIES
7.1 Traffic Control Devices
7.2 On-site Roads Signing
7.3 Highway Signing
7.4 St. Charles County Traffic Signals

TABLE 5.1.5-21 Results of Modified Value Engineering: Site Roads System Analysis

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]	Advantages/Disadvantages	Preferred Alternative
1. Dust Control			
Equipment in use on site (5.0).	Provide separate water trucks on clean and dirty roads. Use separate water trucks for dust control on clean and dirty roads. Provide a clean path surrounding the site so that clean water trucks do not cross dirty roads. 1	**Advantages:** Minimizes contamination of equipment. Very low impact on environment. No added material for cleanup demolition. Mobility. Little work involved (one driver/truck). Equipment used in other areas on site. **Disadvantages:** Must operate trucks constantly on hot, dry or windy days; duration of dust control limited. Source of large quantities of water not yet identified.	Use water trucks to control dust on site roads; use different trucks for clean and dirty roads. Provide a continuous clean path around the site perimeter so that clean trucks can travel around the site without crossing dirty roads.
Make use of equipment being used for dust control in other areas of the site.	Large-size gravel and water trucks. Use large-size stones at the top of the gravel surface so that dust settles in interstices. Use water trucks as in alternative (1) as needed. 2	**Advantage:** Possibly longer period of dust control than with water alone. **Disadvantage:** May be more difficult to obtain desired gravel sizes. More complicated construction.	

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TABLE 5.1.5.21 Results of Modified Value Engineering: Site Roads System Analysis (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]	Advantages/Disadvantages	Preferred Alternative
Length of dust control (8.0). Dust control should last as long as possible after the dust control method is applied. Minimize impact on environment (15.0). Minimize use of materials which adversely affect the environment. Public perception (9.0). Public acceptance of dust control method and effectiveness of method used. Minimize equipment contamination (3.0). Minimize contamination of equipment used to control dust on contaminated roads. Minimize work involved (5.0). Dust control method should be simple, not labor-intensive.	Sprinkler system. drop Install centrally controlled sprinkler system to water site roads as needed.	**Advantages:** Ability to water dusty road immediately without waiting for water truck to arrive. Possibly less impact on construction process (vehicles do not have to wait behind slow-moving water trucks). Can run sprinklers to spray equipment continuously. **Disadvantages:** Added material to disposal cell (piping and sprinkler heads). Work involved in installation may impact cell construction. Water trucks may be needed in addition to sprinklers to follow and spray equipment. System will be difficult to move when site roads are moved.	
Impacts on cell construction (11.0). Dust control method should not interfere with cell construction or other construction on site. Availability of materials (3.0). The materials used in the method of dust control should be readily available and easily replenished.	Resurface roads periodically. drop Resurface roads as equipment breaks down gravel surface and creates more dust. Use water trucks as in alternative [1] as needed.	**Advantage:** Possibly controls longer than water alone. **Disadvantages:** Adds more material to be demolished. Majority of dust may come from equipment wheels/tracks, so gravel road dust is probably not a big concern.	

TABLE 5.1.5.21 Results of Modified Value Engineering: Site Roads System Analysis (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives (Final Rating)	Advantages/Disadvantages	Preferred Alternative
	No clean/dirty water trucks. drop Use the same water trucks to control dust in all areas within the site boundaries. Decontaminate trucks on dirty roads before travel on clean roads.	**Advantage:** Possibly fewer trucks needed on site. **Disadvantages:** Added time and work involved to decontaminate water trucks. Water trucks may need to constantly follow construction equipment on both clean and dirty roads.	
	Cementitious binder and water trucks as needed. drop Use a cementitious binder (lime, Portland cement, pc + pozzolan) in the gravel surface to bind dust. Water roads as needed to control dust falling on surface.	**Advantage:** Less use of water trucks required due to less dust generated from road surface. **Disadvantages:** Adds slightly more material to demolish. May need water trucks just as often to control dust falling on surface from equipment.	
	Asphaltic binder + water trucks. drop Spray gravel roads with petroleum-based binder (road oil). Water roads as needed for dust falling on surface.	**Advantage:** Less use of water trucks due to less dust from road surface. **Disadvantages:** Adding more contaminants to site. May need water trucks just as often for dust falling on surface from equipment.	

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TABLE 5.1.5.21 Results of Modified Value Engineering: Site Roads System Analysis (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Rating]	Advantages/Disadvantages	Preferred Alternative
2. Demarcation of Clean/Dirty Roads				
Ease of construction (3.0). Materials used to designate roads should be easy to obtain and erect. Minimize cleanup demolition (4.0). Minimize amount of contamination or minimize amount of material to be demolished and placed in disposal cell.	Wooden stakes with colored flags. Nail colored flags or pieces of colored cloth to wooden stakes. Drive stakes into shoulders of clean roads and connect stakes with string or streamers.	1	**Advantages:** Looks like a fence/barrier. Very good visibility. Good mobility. Ease of construction. Resistant to wind/weather. **Disadvantages:** Must be demolished and added to disposal cell after use.	Nail colored flags or pieces of colored cloth to wooden stakes. Drive stakes into shoulders of clean roads and connect stakes with string or streamers.
	Rubber highway lane markers. Place highway lane markers on shoulders of clean roads. These are colored rubber/plastic tubes with reflectors at the top and heavy rubber bases.	2	**Advantages:** Very good visibility (tall, yellow). Very good mobility. Easy to place. Can be decontaminated and reused. Fairly heavy base; resists wind. **Disadvantages:** Can blow over in high winds. Must be spaced close together, or vehicles may drive in between them.	
	Construction cones. Place florescent reddish orange cones along edges of clean roads.	3	**Advantages:** Very good visibility and mobility. Can be decontaminated and re-used. Easy to obtain and place on roadsides. **Disadvantages:** May blow away in high wind. Must be closely spaced to be effective. Common; may be ignored.	

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TABLE 5.1.5.21 Results of Modified Value Engineering: Site Roads System Analysis (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives (Final Rating)	Advantages/Disadvantages	Preferred Alternative
Re-use (3.0). Can the materials be decontaminated and re-used? Visibility (10.0). Markers should be clearly visible to approaching vehicle operators. The markers should appear as a barrier to vehicles approaching from improper directions. Resilience (6.0). Markers should not blow away or wash away in rain. Mobility (5.0). Markers will move as site road alignments change.	Erosion control fencing. 4 Place colored erosion control fencing along edges of clean roads.	**Advantages:** Very effective; an obvious barrier with great visibility. Can be decontaminated and re-used. Good mobility, easy to place. **Disadvantages:** Less mobile than items that sit on top of ground. Requires a lot of fencing.	
	Painted metal rods. drop Drive painted metal rods into edges of clean site roads. Connect rods with string or streamers.	**Advantages:** Looks like a fence/barrier. Very good visibility and mobility. Can be decontaminated and re-used. Very resilient. Easy to place. **Disadvantages:** More likely to be demolished than decontaminated and re-used; more difficult to deal with than wood stakes.	

TABLE 5.1.5-22 Observational Method: Site Roads System Analysis

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
1. Dust Control				
Use water trucks to control dust on site roads; use different trucks for clean and dirty roads. Provide a continuous clean path around the site perimeter so that clean trucks can travel around the site without crossing dirty roads.	Clean water trucks will travel only on clean roads, and dirty water trucks will travel only on dirty roads.	Vehicles will travel on improper road (eg., dirty trucks will travel on clean roads).	None/Very Low	None (See MVE on demarcation of clean/dirty roads.) Vehicles will have to exit at the south decontamination pad.
	Clean water trucks will be filled in a clean area.	Clean and dirty water trucks will be filled at the same location.	Very Low	Clean access must be provided to water source, or water trucks must be decontaminated before traveling on clean roads.
	Clean water trucks will be able to travel all the way around the site perimeter without crossing dirty roads.	None	–	–
2. Demarcation of Clean/Dirty Roads				
Wooden stakes with colored flags or pieces of cloth.	Wooden stakes with colored cloth or flags will be driven into the shoulders of clean site roads to provide a visible barrier to vehicles transporting contaminated materials.	A more definite, highly visible barrier is required.	Very Low	Use rubber highway lane markers or colored erosion control fencing to mark clean roads.

TABLE 5.1.5-23 Data Quality Objectives: Site Roads System Analysis

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
1. Dust control			
Vehicles will travel on improper roads.	Vehicles will have to exit at the south decontamination pad.	None	None
Clean and dirty water trucks will be filled at the same location.	Clean access must be provided to water source, or water trucks must be decontaminated before traveling on clean roads.	Is there an existing water source north of the CMSA that can be revitalized to provide a source of water for clean water trucks? Will the fire hydrant by RCRA storage building still exist to provide a water source for dirty water trucks?	Determine condition of existing water line north of CMSA or surrounding area.
Clean road ends at clean soil stockpile; no continuous route is provided around site perimeter.	Clean water trucks turn around at end of clean road and head north over previously watered roads.	None	None
2. Demarcation of Clean/Dirty Roads			
A more visible, sturdier barrier than wooden stakes and streamers is required.	Use rubber highway lane markers or colored erosion control fencing to mark clean roads.	None	None

TABLE 5.1.6-1 Design Storm Parameter Matrix

Design Activity	Return Period (years)	Storm Duration (hours)	Storm Depth (inches)
Raffinate Pits			
Haul roads (drainage)	25	6	4.52
Retention pond	25	24	6.02
Site Drainage Channels			
Operation	25	6	4.52
Permanent	100	24	8.21
Chemical Plant Restoration			
Soil excavation	2	24	3.28
Building Dismantling			
Foundation removal	2	24	3.28
Waste Treatment Plant			
Construction	25	6	4.52
Operation	25	6	4.52
Site Water Treatment Plant			
Construction	25	6	4.52
Operation	25	6	4.52
MSA			
Operation	25	6	4.52
TSA			
Construction	25	6	4.52
Operation	25	6	4.52
Disposal Facility			
Construction	25	6	4.52
Operation	25	24	6.02
Construction of cover	25	6	4.52
Disposal Cell/Chemical Plant			
Water control dikes	25	6	4.52
Retention pond	25	24	6.02
Holding Ponds			
EPA "Waste Pile"	25	24	6.02
Storm Water Management/NPDES	10	24	4.76
Road/Barrier Crossings	10	24	4.76
Final Disposal Cell Cover	PMP	6	38.4

TABLE 5.1.6-2 Discharges and Runoff Curve Numbers for the Five Existing On-Site Watersheds

Watershed	*Q_{peak} (cfs) for 24-hour Storms			Composite Runoff Curve No. (RCN)
	2-year	10-year	25-year	
1	28.6	94.1	152.2	78
2	1.5	3.5	5.5	70
3	1.8	4.1	6.4	70
4	8.5	25.5	41.9	69
5	13.1	20.4	26.6	90

* Q_{peak} = Peak channel discharge.

Source: (Ref. 47)

TABLE 5.1.6-3 Discharge Values for Existing Ash Pond Isolation Dike Structure and Frog Pond

	Ash Pond Isolation Dike Spillway Stage = 8.0 ft Capacity = 7.9 acres-ft				Frog Pond Spillway Stage = 8.32 ft Capacity = 3.33 acres-ft			
Storm (24-hr)	Q_{peak} (cfs)		Peak Volume (acres-ft)	Peak Stage (ft)	Q_{peak} (cfs)		Peak Volume (acres-ft)*	Peak Stage (ft)
	In	Out			In	Out		
2	25.0	0.4	2.1	4.3	69.4	29.8	4.3	9.2
10	52.9	0.5	4.5	6.2	115.8	88.4	4.2	9.1
25	79.5	0.6	6.9	7.5	166.0	126.2	4.3	10.7
100	129.3	8.8	8.3	7.4	226.6	187.1	4.4	11.7

*Note: Standing water at a depth of 5.1 ft within Frog Pond uses 1.5 acre-ft of the available storage.

TABLE 5.1.6-4 Results of Modified Value Engineering: Handling of Runoff

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Minimize off-site release of potentially contaminated runoff. Minimize cost. Minimize construction requirements. Minimize cross contamination.	Contain no potentially contaminated runoff. (No Action)	**Advantages:** No construction required; no treatment required; minimal interference with other activities. **Disadvantages:** High potential for off-site release of contaminants and cross contamination in runoff water.	Contain potentially contaminated runoff from contaminated soil excavations, contaminated soil temporary stockpiles, uncovered waste in cell, and runoff from dirty haul roads for testing and/or treatment.
	Contain all potentially contaminated runoff.	**Advantages:** Minimal or no chance for off-site release of contamination or cross contamination. **Disadvantages:** Large areas of site required for containment of runoff; cost and construction requirements will be high relative to other options.	
	Contain potentially contaminated runoff from uncovered material in disposal cell only.	**Advantages:** Low cost and construction requirements. Contains runoff from the most highly contaminated material. Will only interfere with the disposal cell placement activities. **Disadvantages:** Runoff from other contaminated areas potentially can spread contamination off-site and to clean areas.	
	Contain potentially contaminated runoff from uncovered material in disposal cell and contaminated soil excavation areas.	**Advantages:** Interference with other activities would not be great since containment facilities could all be located within work areas.	

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TABLE 5.1.6-4 Results of Modified Value Engineering: Handling of Runoff (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Contain potentially contaminated runoff from material in disposal cell, contaminated soil excavation areas, and contaminated soil stockpiles.	**Disadvantages:** Would require construction of temporary sumps, ponds, and conveyance system. **Advantages:** Potentially contaminated water from the most highly contaminated areas would not be released off-site or cause cross contamination. **Disadvantages:** Extra cost and construction effort required. Minimal space in stockpile areas would interfere with placement activities.	

TABLE 5.1.6-5 Drainage Areas, Runoff Coefficients, and Peak Discharges During Cell Construction Sequence

AREA	Sequence 1			Sequence 2			Sequence 3			Sequence 4			Sequence 5		
	AREA (acres)	RCN	Peak Discharge (cfs)	AREA (acres)	RCN	Peak Discharge (cfs)	AREA (acres)	RCN	Peak Discharge (cfs)	AREA (acres)	RCN	Peak Discharge (cfs)	AREA (acres)	RCN	Peak Discharge (cfs)
A	4.2	91	11.2	4.2	91	11.2	4.2	91	11.2	4.2	91	11.2	4.2	91	11.2
B	6.3	91	19.0	6.3	91	19.0	6.3	91	19.0	6.3	91	19.0	6.3	91	19.0
C	11.5	81	28.0	11.6	84	29.2	11.6	84	29.2	11.6	84	29.2	11.6	84	29.2
D	3.6	94	13.2	2.3	94	8.5	2.3	94	8.5	0.0	0	0.0	0.0	0	0.0
E	5.5	93	20.1	5.5	93	20.1	5.5	93	20.1	5.5	93	20.1	5.5	93	20.1
F	0.5	77	1.2	0.5	77	1.2	0.5	77	1.2	3.0	84	11.2	3.0	84	11.2
G	17.1	81	49.8	18.3	71	19.7	18.3	71	21.4	22.0	81	52.0	38.1	75	40.2
H	10.4	90	25.2	10.4	90	25.2	10.4	90	25.2	10.8	89	23.5	0.0	0	0.0
I	1.1	70	1.6	1.1	71	1.8	1.1	71	1.8	1.1	71	1.8	1.1	71	1.8
J	9.8	72	15.3	12.3	72	19.0	12.3	72	19.0	14.3	72	22.1	19.7	72	27.0
K	4.8	71	5.5	4.8	71	5.5	4.8	71	5.5	4.8	71	5.5	4.8	71	5.5
L	2.9	71	3.4	2.9	71	3.4	2.9	71	3.4	2.9	71	3.4	2.9	71	3.4
M	4.8	88	23.4	4.8	88	23.4	4.8	88	23.4	4.8	88	23.4	4.8	88	23.4
N	15.8	80	28.3	15.9	87	33.2	15.9	87	33.2	0.0	0	0.0	0.0	0	0.0
O	24.6	82	60.5	24.7	82	47.5	24.7	82	47.5	36.2	72	56.0	36.2	67	43.0
P	2.4	74	4.1	2.4	74	4.1	2.4	74	4.1	2.4	74	4.1	2.4	74	4.1
Q	27.1	78	39.4	19.2	83	38.0	19.2	83	38.0	10.7	91	24.4	10.6	91	25.7
R	16.2	100	0.0	16.2	100	60.2	18.1	58	10.2	18.1	58	9.3	18.1	58	9.3
S	8.2	100	0.0	8.2	100	0.0	8.2	100	27.7	8.2	88	18.9	8.2	88	18.9
T	9.1	88	20.7	12.7	83	24.4	12.7	83	24.4	12.7	83	24.4	11.7	83	22.8
U	12.3	98	27.3	14.3	86	29.0	14.3	58	5.8	23.0	58	15.5	12.8	58	4.9
V	1.7	95	11.0	1.7	95	11.0	1.7	95	11.0	1.7	95	11.0	1.7	95	11.0
W	10.8	98	26.1	10.8	98	26.1	10.8	98	26.1	10.8	88	19.4	10.8	88	19.4
X	2.5	100	0.0	2.5	100	6.5	2.5	88	4.3	2.5	72	3.9	2.5	88	1.9
Y	10.2	98	23.0	10.2	98	23.0	10.2	98	23.0	10.2	98	23.0	10.2	98	23.0
Z	1.3	66	0.7	1.3	68	0.8	1.3	66	0.8	1.3	66	0.8	1.3	66	0.6
AA	6.4	68	3.2	6.4	67	6.2	6.4	67	6.2	6.4	67	5.2	6.4	67	5.2
AB	5.9	58	3.8	5.8	67	5.8	5.8	67	5.8	5.8	67	5.8	4.8	67	4.6

Source: (Ref. 143)

TABLE 5.1.6-6 Comparison of Peak Discharges for the Cell Construction Sequence

Sediment Basin	Sequence*				
	1	2	3	4	5
	Peak Discharge (cfs)				
1	89	107	107	112	118
4	35	35	35	29	100
5	28	29	9	16	7

* Shown in detail on Figure 5.1.6-4 through 5.1.6-8

TABLE 5.1.6-7 Site Drainage Specification Outline

1. Temporary erosion and sediment control a. Silt fences b. Straw bales c. Mulching/seeding d. Temporary diversions
2. Culverts
3. Riprap protection and filters a. Riprap protection b. Granular filters c. Plastic filters
4. Grade control structures
5. Erosion control mats
6. Detention ponds a. Lining b. Outlet works
7. Sump pits
8. Dention basins a. Outlet works b. Liners
9. Vegetated waterways
10. Permanent drainage channels

TABLE 5.1.7-1 Summary of Borrow Material Criteria

Design Feature Location	Component/Function	Material Type	USCS[a] Symbol	Remarks
Basal liner and foundation system[i] (includes foundation preparation soils).	Foundation preparation (filling of holes left by excavation of building foundations, sewer lines, and contaminated soils).	Clay	CL-CH[b]	k[c] $\leq 1 \times 10^{-7}$ cm/sec; 20 < PI[d] <40; organic content <2%. $P^{(f)}_{200}$ > 50%; P_4 >90%; D_{max} ≤2 in.
	Basal liner	Clay	CL-CH[b]	Same as above.
	LCRS or LDCRS	Sand-gravel	SP-GP	k[c] ≥ 1.0 cm/sec; $D^{(e)}_{10}$ ≥ 1.5 mm; Cu < 6; D_{max} < 3"; P_{200} < 5%.
	Filter layer	Sand	SW	0.8 mm ≤ D_{10} ≤ 1.5 mm; CU < 6; D_{max} <3 in.; P_{200} < 5%.
	Protective soil layer	Silty clay	CL-CH	Organic content < 2%.
Disposal cell[i] Top slope cover.	Radon barrier[b]	Clayey, silty, soils	CL/ML/SC	20 < PI < 40; radon diffusion coefficient < 0.01 cm²/sec; organic content < 2%; P_{200} > 20%; P_4 > 90%; D_{95} < 1".
	Infiltration barrier[b]	Clay	CL-CH[a]	k[c] ≤ 1×10^{-8} cm/sec; 20 PI < 40; organic content < 2%.
	Bedding/drain (Type 1)	Gravelly sand	SW	Rock quality score[h] > 60; $P_{3/8}$ > 80%; P_{10} < 10%.
	Biointrusion layer	Gravel	GP	1 in. ≤ Rock Diagram ≤ 4"; rock quality score[h] > 70.
	Filter layer	Silty, clayey sand	SM-SC	Gs ≥ 2.53; Na_2SO_4 soundness ≥ 10%; D_{85} = ½-1 in.; P_{200} < 25%.
	Rooting medium Layer 2	Silty, clay, clayey silt, clayey sand	SC/CL/CH/ML	Clay content > 20%.
	Rooting medium, Layer 1	Loam	SM/ML	Organic content ≤ 5%; sand = 30-50%; Silt = 30-50%; clay = 0-20%.
	Gravelly topsoil	Silty, clayey gravel	GM-GC	Organic content > 3%; P_2 = 100%; P_1 = 30-60%; P_{200} = 15-30%.

TABLE 5.1.7-1 Summary of Borrow Material Criteria (Continued)

Design Feature Location	Component/Function	Material Type	USCS[a] Symbol	Remarks
Disposal cell side slope cover[i]	Bedding/filter (Type 2)	Gravelly sand	SW	Rock quality score[h] > 60; D_{100} = 3 in.; D_{60} = 3/8 - 1-1/2"; P_4 < 5%.
	Riprap layer	Gravels	GP	D_{100} = 8-12 in.; D_{50} = 4-6 in.; D_{10} < 1 in.; P_{200} < 2%; rock score > 70.
Clean-fill dikes[e]	Perimeter encapsulation	General fill	ML, CL, SC, CH, SM, GM, GC	Organic content < 2%. D_{100} < 6-in. D_{85} < 3-in.
Haul roads and construction[j]	Aggregates subbase	Silty, clayey sand, gravel	SM-SC/ GW	2-1/2-in. maximum gradation; R-Value > 50.
	Aggregates base	Silty, clayey sand, gravel	SM-SC/ GW	3/4-in. or 1-1/2-in. maximum gradation; R value > 78.
Site restoration and site grading[k]	Site restoration	General fill	See clean-fill dikes	Organic content < 2%; D_{max} < 3 in.; P_{200} > 10%.
Drainage channels/ ditches	Site drainage	Gravels[g]	GP	Rock quality score[h] > 60.

Notes:

(a) Unified Soil Classification System (USCS).
(b) CL, CH, ML, SC, SM, SP, SW, GP, GM, GL are USCS symbols designating soil type, e.g. CH stands for highly plastic clay.
(c) Saturated hydraulic conductivity or permeability obtained in the Triaxial Permeability Test specified in COE EM 1906.
(d) PI is Plasticity Index of soils obtained from tests specified in ASTM D4318-84.
(e) D_{10} is the soil diameter at which 10% of the soil weight is finer.
(f) P_x is defined as the percentage of material finer than sieve size x or No. x sieve.
(g) To be determined, but expected to be gravel-sized to boulder-sized rock particles.
(h) Rock Quality Score per Table 5.1.7.1-3
(i) See Section 5.2.
(j) See Section 5.1.5.
(k) See Section 5.1.2.
(l) R-Valve indicates value resistance value measured by stabilization, per the California Department of Highways requirements.

TABLE 5.1.7-2 Summary of Borrow Material Volumes - Partially-Below-Grade

No.	Component/Function	Location	Function	Volume (x1000 yd^3) CSS	VIT
A. Low Permeability Material					
1	Foundation preparation	Cell foundation	Filling of holes left by excavation; also, same as No. 2.	To be determined.	
2	3-ft clay bottom system	Cell basal liner and LCRS	Prevents any migration of wastes and waste/leachate into the foundation soil and groundwater.	196	143
3	3-ft radon barrier	Cell top slope	Minimizes the emanation of radon gases from the radioactive waste.	194	142
4	18-in. infiltration barrier	Cell top slope	Limits infiltration of water into the underlying waste.	105	77
B. Rock or Gravels/Cobbles					
5	1-ft biointrusion system	Cell top slope	Inhibits the penetration of roots and mitigates the growth of deep-rooted vegetation on the cell.	68	49
6	1-ft riprap	Cell side slope	Provides erosion protection for the side slope.	49	42
7	Site drainage	--------	Collects and disposes surface water from the disposal cell area.	To be determined.	
C. Sands or Gravelly Sands					
8	Drain material - 2-ft-6-in. total (2 layers)	Cell basal liner and LCRS	Collects and drains leachate rapidly to prevent the buildup of large seepage and hydrostatic pressure.	133	94
9	Filter layer - 12-in. total (2 layers)	Cell basal liner and LCRS	Prevents piping or migration of finer soil above the filter layer from being washed in through the drainage layer.	53	38
10	1-ft bedding/drain Type 1	Cell top slope	Drains the incident precipitation on the top slope and acts as filter and bedding for the biointrusion layer.	69	50
11	6-in. filter layer	Cell top slope	Acts as filter and bedding for the rooting medium.	33	24
12	6-in. bedding/filter, Type 2	Cell side slope	Drains the incident precipitation on the side slope and acts as filter and bedding for the riprap.	24	21
13	1-ft aggregate subbase	Site roads and CMSA	Transfers and distributes traffic loads to the underlying soil foundation.	To be determined.	
14	6-in. aggregate base	Site roads and CMSA	Receives traffic axle load and transfers it to the subbase.	See above.	

TABLE 5.1.7-2 Summary of Borrow Material Volumes - Partially-Below-Grade (Continued)

No.	Component/Function	Location	Function	Volume (x1000 yd^3) CSS	VIT
D. General Fill					
15	2-ft rooting medium, Layer 2.	Cell top slope	Provides a growth medium for the desired vegetation and frost protection.	130	95
16	Clean-fill dike	Cell perimeter encapsulation	Forms the perimeter encapsulation system for disposal cell.	983	783
17	Site road and CMSA subgrade.	Site road and CMSA	Fills depressions caused by remedial action and demolition work.	To be determined in site roads task.	
18	Site restoration.	----------	Restores site and blends the disposal facility with adjacent existing topography.	To be determined in site closure task.	
E. Organic Rich Soil					
19	6-in. rooting medium, Layer 1.	Cell top slope	Provides a growth medium for the desired vegetation.	33	24
20	6-in. gravelly topsoil.	Cell top slope	Provides growth medium for the desired vegetation and erosion resistance.	32	24

Notes: (1) The thickness represents the most current design. They may change for future designs.

TABLE 5.1.7-3 Rock Quality Scoring Criteria

	Weighting Factor			Score										
	Lime-stone	Sand-stone	Igne-ious	10	9	8	7	6	5	4	3	2	1	0
Specific Gravity	12	6	9	2.75	2.70	2.65	2.60	2.55	2.50	2.45	2.40	2.35	2.30	<2.3
Absorption (%)	13	5	2	0.1	0.3	0.5	0.67	0.83	1.0	1.5	2.0	2.5	3.0	>3.0
Sodium Sulfate (%)*	4	3	11	1	3	5	6.7	8.3	10	12.5	15	20	25	>25
Abrasion (%)**	1	8	1	1	3	5	6.7	8.3	10	12.5	15	20	25	>25
Schmidt Hammer	11	13	3	70	65	60	54	47	40	32	24	16	8	<8
Tensile Strength (psi)	5	4	10	1400	1200	1000	833	666	500	400	300	200	100	<100

Notes:
1. Scores derived from Lindsey (Ref. 141).
2. Any rock to be used must be qualitatively rated at least "fair" in a petrographic examination conducted by a geologist experienced in petrographic analysis.
3. Test methods should be standardized and should be those used in DePuy (Ref. 142).

* 5 cycles
** 100 revolutions

TABLE 5.1.7-4 Observational Method: General Borrow Material Design

Component Discussed	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
Basic cover system for top and side slopes.	Top slope - vegetated cover.	Top slope r Riprap.	Low	Increase quantity of riprap – possibly 1 in. -4 in. size. No rooting medium needed
	Side slopes - riprap.	Site slopes – vegetated cover.	Very Low	Major changes in design – side slopes, rooting medium, etc.
Change in cell configuration.	Configuration as in Figure 5.1.7-1.	Change in height.	High	Larger volume of materials may be required – most significantly clean-fill dike material and riprap.
		Change in footprint area.		Will change size of riprap required. The effect will be minimal, unless change is very significant.
		Change in depth of excavation. (all these are interrelated)		Change in volume available for clean-fill dike; thus, change in volume required from off-site sources.
Change in waste placement strategy.	Strategy as in Section 5.2.6.	More stratified configuration.	Low	Less or more thickness of radon barrier volume will be required (see Section 5.2.7.2.2).
Change in permeability requirements for low permeability layers.	As in Table 5.1.7-1.	The requirement for 10^{-6} cm/sec for infiltration barrier may be relaxed to a higher value.	Medium to High	May not require an infiltration barrier. The radon barrier may serve as both.
Change in plans for off-site roads, CMSA, site restoration.	As in Sections 5.1.4 and 5.1.5 and Section 5.4.	Realignment of site roads and CMSA change in final site grading plans.	Medium	Changes in volume required.

TABLE 5.1.7-5 Assessment of Data Needs: General Borrow Material Design

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Top slope - riprap or side slope - vegetated cover.	Increased quality of riprap for top slope. Elimination of gravelly topsoil and rooting medium layers.	Is there a change in cover plans?	
Change in height, footprint area or depth of excavation of disposal cell.	Change in volumes of materials required, partially clean-fill dike material. May change riprap size significantly.	Find height, footprint and depth of excavation.	Finalize configuration.
Changed waste placement strategy, effecting radon barrier.	See Section 5.2.7.2.2.	Nature of change; radioactivity of the wastes in sequence.	Radioactivity levels in wastes to be placed in top 10 ft -15 ft below radon barrier.
Relaxation of permeability for infiltration barrier.	May eliminate infiltration barrier.	Exact permeability requirements.	Establish permeability required.
			Establish type of soil and percent bentonite to be added (if required by testing).
Change in site road alignment, CMSA location or sizes.	Changes in required volumes of various materials.	Final plans for site roads, CMSA and site grading.	Finalize plans.

TABLE 5.1.7-6 Testing Methods and Specifications

No.	Component	Test Method	ASTM Test Designation	Frequency of Tests ***	Properties Required During Borrow Operation
Basal Liner and Foundation System					
1	Foundation preparation and clay bottom	Gradation	D422	1/5000 yd^3	* P_{200} > 50%; P_4 > 90%; ** $D_{max} \le 1" - 2"$.
		Atterberg Limit	D4318	1/200 yd^3	20 < PI < 40.
		Organic content	D2974	***	Organic matter < 2%.
2	Drain material	Gradation	D422	1/10000 yd^3	0.8 mm ≤ D_{10} ≤ 1.5 mm; Cu < 5; D_{max} < 3"; P_{200} < 5%.
3	Filter layer	Gradation	D422	1/10000 yd^3	Cu < 20.
Top Slope Cover					
4	Radon barrier	Gradation	D422	1/5000 yd^3	Same as Item 1 except D_{95} <1 in.; P_{200} > 20%.
5	Infiltration barrier	Same as Item 1	*		
6	Bedding/drain Type 1	Gradation Durability	D422 See Item 15	1/10000 yd^3	$P_{3/8}$ > 80%; P_{10} > 90%; Rock quality score > 60.
7	Biointrusion system	Gradation durability	D422	1/10000 yd^3	
		Durability -Specific gravity -Absorption -Sodium sulfate -Abrasion	 C127 C97 C88 C241	1/10000 yd^3	Rock quality score > 70.

TABLE 5.1.7-6 Testing Methods and Specifications (Continued)

No.	Component	Test Method	ASTM Test Designation	Frequency of Tests ***	Properties Required During Borrow Operation
8	Filter layer	Gradation Specific gravity Sodium sulfate Soundness	D422 C127 C88	1/10000 yd^3 1/10000 yd^3 1/10000 yd^3 1/10000 yd^3	D_{85} = 1/2 - 1 in.; P_{200} < 25%. Specific gravity > 2.53. $Na_2 So_4$ soundness ≥ 10%.
9	Rooting medium, Layer 2.	Gradation.	D422	***	Clay content 20%.
10	Rooting medium, Layer 1.	Organic content gradation.	D2974 D422	1/10000 yd^3 1/10000 yd^3	Organic matter 5%. Sand = 30% - 50%; Silt = 30% - 50%. Clay = 0% - 20%.
11	Gravelly topsoil.	Gradation. Organic content.	D422 D2974	1/10000 yd^3 1/10000 yd^3	P_2 = 100%, P_1 = 30% - 50%; P_{200} = 15% - 30%. Organic matter > 3%.
Side Slope Cover					
12	Bedding/filter Type 2.	Gradation.	D422	1/10000 yd^3	D_{100} = 3 in.; D_{50} = 3/8 in. - 1-1/2 in.; P_4 < 5%.
13	Riprap.	Gradation. Durability. -Specific gravity -Absorption -Sodium Sulfate -Abrasion	D422 C127 C97 C88 C241	1/10000 yd^3 1/10000 yd^3	D_{100} = 8 in. - 12 in.; D_{50} = 4 in. - 6 in.; D_{10} < 1 in.; P_{200} < 2%. Rock quality score > 70.

TABLE 5.1.7-6 Testing Methods and Specifications (Continued)

No.	Component	Test Method	ASTM Test Designation	Frequency of Tests ***	Properties Required During Borrow Operation
Clean-Fill Dikes					
14	General fill.	Organic content Gradation	D2974 D422	*** ***	Organic matter < 2%; D_{max} < 3 in.; P_{200} > 10%.
Haul Road and Construction Pad					
15	Aggregate subbase.	Gradation.	D422	1/10000 yd^3	2-1/2 in. maximum gradation; R-value > 50.
16	Aggregate base.	Gradation.	D422	1/10000 yd^3	3/4 in. or 1-1/2 in. maximum gradation; R-value > 78.
Site Restoration					
17	General fill.	Organic content gradation.	D2974 D422	*** ***	Organic matter < 2%; D_{max} < 3 in.; P_{200} > 10%.
Drainage Channels/Ditches					
18	Site drainage.	Gradation. Durability.	D422 Same as Item 14	1/10000 yd^3 1/10000 yd^3	Depends on the final size of the drainage area; Rock quality score 70.

* P_x = percentage of material finer than size x or No. x sieve. D_x = soil diameter at which X% of the soil weight is finer.
** Maximum grain size diameter.
*** Perform one test for each borrow site at the beginning of borrow operations. Perform additional tests as necessary to ensure material conforms to the specifications.
**** The frequency of test is a recommendation. They may be changed during final design.

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TABLE 5.1.7-7 Results of Modified Value Engineering: Field Testing Frequency Strategy

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Ranking]	Advantages/Disadvantages	Preferred Alternative
Gives most reliable results for the entire volume. Can be effectively planned in advance. Does not depend heavily on human factors, e.g., experience of field engineer/geologist. Backed up by previous experience, precedence and engineering judgement.	Predetermined specified freqency. Frequency based on statistical criteria.	**Advantages:** Predetermined frequency can be planned in advance, does not depend on human factors, and is backed up by previous experience and precedence. **Disadvantages:** In some situations, it may not yield the most reliable results.	Predetermined specified frequency.

TABLE 5.1.7-8 Observational Method: Field Testing Frequency Strategy

Component Discussed	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
Testing frequency for material selection and testing criteria during borrow material production.	Testing shall be performed at a predetermined, specified frequency.	Material at source more varied than anticipated, thus, specified frequency not representative of the desired confidence level.	Low	Higher incidence of rejected samples. Less volume availability than originally anticipated.
		Properties in field close to desired properties, requiting more tests to accept or reject the materials.	Medium	Same as above.

TABLE 5.1.7-9 Assessments of Data Needs for Field Testing Frequency Strategy

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Material at source more varied (less uniform) than anticipated. Requires more tests than pecified frequency for the desired confidence level.	Major, particularly if expected available volume is low to start with.	Level of variation.	Extensive data collection, as is being done in Study 5A (Ref. 51) and planned for Study 5C (Ref. 52). The results of these studies may indicate need for additional studies.
		Which materials, and how much is acceptable?	
		Can the acceptable materials be visually identified?	
		How easy is it to obtain the acceptable materials?	
Properties in field close to desired properties, requiring tests at higher frequency.	Same as above.	How much of the material is acceptable?	Same as above.
		Can acceptable materials be visually identified?	
		How easy is it to obtain acceptable materials?	

TABLE 5.1.7-10 **Results of Modified Value Engineering: Borrow Source for Low Permeability Material**

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Ranking]	Advantages/Disadvantages	Preferred Alternative
1. Borrow Source			
Distance from site and accessability (e.g. presence of roads. Not environmentally or archeologically sensitive. Adequate volume of material available, with contingencies. Thickness of overburden to be removed. Uniformity of the deposit. Quality of the clay: plasticity. Location w.r.t. water table. Site restoration required.	Area 1: Weldon Spring Training Area owned by the Department of the Army (Figure 5.1.7-2).	Will be presented in detail in Supporting Study 5A (Ref. 61).	Area 3.
	Area 2: A portion of the Busch Wildlife Area owned by the Missouri Department of Conservation (MDOC) (Figure 5.1.7-2).		
	Area 3: A portion of the Weldon Spring Wildlife Area owned by the Missouri Department of Conservation (Figure 5.1.7-3).		

TABLE 5.1.7-11 Observational Method: Low Permeability Borrow Material Source

Component Discussed	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
Borrow source for low permeability borrow material.	Source from Area 3 (A portion of the Weldon Spring Wildlife Area owned by the Missouri Department of Conservation. This area is located about 1 mi east of the Weldon Spring site and about ½ mile southeast of Francis Howell High School and east across State Route 94 (see Figure 5.1.7-3).	Not available due to environmental/regulatory considerations.	Very Low	Change to another source.
		Sufficient volume of suitable material not found during actual operations.	Very Low	Extend area and depth of excavation.
				Go for another source.
		Also designated as source of clean-fill dike material.	Very High	Need to investigate and acquire a much wider area.

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TABLE 5.1.7-12 Data Assessments of Data Needs: Low Permeability Borrow Material Source

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Borrow Source 3 (portion of Missouri State Wildlife) not available.	Major. New source may be required.	Designation of a new source.	Perform Study 5A again with the next best Fencorm alternative.
Sufficient volume of suitable material not found during actual operations.	Area of excavation or depth of excavation has to be increased.	Availability of additional area. Suitability of deeper soils.	Soils data and information on availability.
Also designated as source of clean-fill dike material.	The borrow excavation plan, transportation method and site restoration plans need to be revised.	Total area available for combined borrow material. Soils in the area. Restoration plans and requirements.	Availability of the area from environmental, regulatory and public perception standpoints. Subsurface soils information in the area.

TABLE 5.1.7-13 Borrow Sources: Summary Data

Rock Source	Rock Type	Available Sizes (Inches)	Estimated Volume (cy)		Haul Method Distance		Plant Facility		Road Conditions		Remarks/ Recommendations
			At Source	Req.	Truck	Rail	Crusher	Screening	Haul	Access	
Defiance Quarry; Defiance, MO	Limestone	<1 in. to 18 in.	24 M 89 M	150 K	6 mi		Yes	Yes	Hwy. 94 & DD-Rd.	OK	P.R. = 50 - 57
Joerling Quarry; New Melle, MO	Limestone	<1 in. to 18 in.	20 M	150 K	12 mi		Yes	Yes	Hwy. 94 & F-Rd.	OK	P.R. = 57
Weber Quarry; O'Fallon, MO	Limestone	<1 in. to 18 in.	20 M	150 K	12 mi		Yes	Yes	Hwy. 70 & K-Rd.	OK	P.R. = 34
Weber Quarry (N. Pit); St. Louis County	Limestone	<1 in. to 18 in.	20 M	150 K	17 mi		Yes	Yes	Hwy. 70 & Hwy. 270	OK	P.R. = 64 - 69
St. Charles Quarry; St. Charles, MO	Limestone	<1 in. to 18 in.	9 M	150 K	11 mi		Yes	Yes	S. River Rd. & Hwy. 70	OK	P.R. = 22-53
St. Francois Quarry; Farmington, MO	Dolomite	<1 in. to 18 in.	2 M	150 K	86 mi		Yes	Yes	Hwy. 67	OK	P.R. = 62
Quality AGG Quarry; Piedmont, MO	Rhyolite	All sizes	20 M	350 K	40 mi +/-	90 mi +/-	Yes	Yes	Hwy. 34 & Hwy. 49	OK	P.R. = 95 Slightly radioactive
Glacial Sand & Gravel Quarry; Old Monroe, MO	Gravels - glacial sand and gravel	Sand to 2 1/2 in.	20 M	200 K	24 mi		No	Yes	Hwy. 79 & Hwy. 70	OK	Contains 20% igneous origin well rounded, poorly sorted
Winters Bros. Quarry; St. Louis County	Gravels - residual chert	Sand to 2 1/2 in.	20 M	200 K	32 mi		No	Yes	Hwy. 30 & Hwy. 141	OK	>95% chert, well rounded poorly sorted

Notes: 1. P.R. = Preliminary Rock Score (for definition see Table 5.7.1-3)
M = Million
K = Thousand
2. P.R. < 50 is unacceptable; 50 - 65 is marginal; 65 - 80 is acceptable; > 80 is preferable

TABLE 5.1.7-14 Assessments of Data Needs: Low Permeability Borrow Material Source

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Borrow Source 3 (portion of Missouri State Wildlife) not available.	Major. New source may be required.	Designation of a new source.	Perform Study 5A again with the next best Pencorm alternative.
Sufficient volume of suitable material not found during actual operations.	Area of excavation or depth of excavation has to be increased.	Availability of additional area. Suitability of deeper soils.	Soils data and information on availability.
Also designated as source of clean-fill dike material.	The borrow excavation plan, transportation method and site restoration plans need to be revised.	Total area available for combined borrow material. Soils in the area. Restoration plans and requirements.	Availability of the area from environmental, regulatory and public perception standpoints. Subsurface soils information in the area.

TABLE 5.1.7-15 Assessment of Data Needs: Clean-Fill Material Borrow Source

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Site not available due to regulatory, environmental, or public perception problems.	Use another alternative site.	Availability of the site.	Regulatory, environmental and public perception issues pertaining to the site.
		Availability of satisfactory soils of sufficient volume.	Investigate the subsurface soil conditions, including location of groundwater table.
Soils at the site are unsuitable or insufficient.	Same as above.	Same as above.	Same as above.

Table 5.1.7-16 Outline of Specifications

1. Earthwork (at the WSWA) for low permeability material, rooting medium Layer 2 and general fill).

    a. Location of site and formations to be used.

    b. Material testing (see Table 5.1.7-6 for type and frequency of testing, as well as the designations for the required standards).

    c. Criteria for acceptibility or rejection. Course of action in case of rejection.

2. Rock and sand materials from commercial sources

    a. Location of approved source: location of facility, type of rock for use.
    b. Gradation (ASTM D-422).
    c. Rock quality (UMTRA requirements).
    d. Criteria for acceptability or rejection. Course action in case of rejection.
    e. Required submittal to indicate the details of the facility.

3. Gravelly topsoil and rooting medium Layer 1.

    a. Gradations.
    b. Organic content.
    c. Criteria for acceptability or rejection. Course action in case of rejection.
    d. Required submittal to indicate the details of the facility.

TABLE 5.1.8-1 Existing Other Facilities

Name	Description
Site water treatment plant (SWTP Train 1)	The SWTP Train 1 is designed to treat contaminated storm water runoff and other impounded site waters. Its design capacity is 80 gpm, with a maximum capacity of 100 gpm.
SWTP Train 2 (Raffinate Pits)	Train 2 is intended to treat waters from Raffinate Pits 1 and 3, and cell leachates high in nitrates. Its design capacity is 40 gpm, with a maximum capacity 50 gpm.
Building 434 storage	Storage for 3,400 drums of TSCA and RCRA wastes that are removed from the chemical plant site, quarry, or vicinity properties.
Access control	Provides personnel and vehicles access to the controlled area.
Electrical utilities	Three electrical distribution lines serve the site. The north line serves the subcontractor laydown area, composite building, showers, and decontamination pad. The east line serves the site guard shack, and the controlled area access gates. The south service serves the administration building, the support trailers, and the SWTP.
Water distribution utilities	Services are furnished by St. Charles County.
Sewer and storm sewer utilities	Sewer and storm sewer piping systems serve the administration area.
Subcontractor trailer and laydown area	An area northeast of the administration building (outside of the controlled area) that is used by subcontractors for employee parking, material and equipment staging, and office space.
ACM storage	Seventy-eight Sea-Land containers are used to temporarily store ACM removed from the chemical plant buildings. They also store contaminated lumber, hardware, and miscellaneous other items.
Radio chemistry laboratory	Provides cleanup verification services for removal of radioactive and chemically contaminated materials from the chemical plant, quarry, and vicinity properties. Provides analysis of air sampling and breathing apparatus filters.
Temporary storage area	Provides storage and staging area for materials being removed from the quarry.
Material staging area	Provides temporary storage and staging area for materials removed from the chemical plant site.
Training facilities	A double-wide trailer that houses training staff offices, storage area, and classroom space.

TABLE 5.1.8-2 Results of Modified Value Engineering: House Laboratory Facilities

Evaluation Criteria (Weight from MVE)	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Ease of delivery of materials. Provide easiest access for delivery of materials to be tested (6). Minimize site space used. Minimize site space required for laboratory buildings, parking, storage, and utility services. (Dropped) Minimize congestion. Minimize overall site congestion by placing laboratory facilities in an area of less long-term activity (3). Ease of personnel access. Provide easy access for laboratory personnel to get to and from the laboratories (3).	House QC/PT and analytical laboratory in separate buildings. Combine laboratories near administration area. Combine laboratories near the south end of the chemical plant site.	Requires more site space. Causes congestion in administration area. Causes congestion in administration area. Provides easy access to laboratory for laboratory workers. Minimizes overall congestion. Hazardous materials do not leave the controlled area. Provides additional office space in the administration building. Laboratories may be able to support each other.	Build a new laboratory facility on the south end of the chemical plant site, which will house the QC/PT and analytical laboratories. The laboratories could be housed in one larger structure, or could be two separate structures sharing parking, storage areas, and utility services.

TABLE 5.1.8-3 Results of Modified Value Engineering: Long-Term Leachate Treatment

Evaluation Criteria (Weight from MVE)	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Minimize cost. Minimize life cycle cost including purchase, maintenance, and operation (3). Minimize maintenance. The less maintenance required, the better (9). Dependability. Equipment must be available and operable when needed (2).	Contract for annual treatment with mobile equipment. Purchase mobile equipment. Use site WTP Train 2.	Minimize maintenance. Minimize cost. May be less available. Higher cost. Higher maintenance. Plant is to large.	Contract for annual treatment with mobile equipment. SWTP Train 2 is too large for long-term treatment of leachate, but it should be kept on-line for the first few years after cell closure to treat construction waste. After construction water stops, a contract should be issued to treat small quantities of leachate that may be generated for many years.

TABLE 5.1.8-4 Observational Method: Long-Term Leachate Treatment

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
Leachate will be generated from the disposal cell.	Less than 50,000 gal/yr will be generated from the disposal cell.	More than 50,000 gal/yr will be generated.	Low	May require more frequent treatment.
		No leachate will be generated	Low	Treatment not required.
	Leachate must be treated.	Treatment as required.	Low	Treatment plant not needed.
		Cell cover fails generating large quantities of leachate.	Low	Small mobile plant cannot process large quantities of leachate. SWTP Train 2 should be reactivated until cover is repaired and leachate flow returns to normal. In addition, an emerging overflow storage pond should be installed to retain excess leachate.

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TABLE 5.1.8-5 Results of Modified Value Engineering: Use of Sea-Land Containers for Storage

Evaluation Criteria (Weight from MVE)	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Adequate size. Storage must provide enough room to store miscellaneous items (12). Minimize congestion. Storage should be located in an area that caused congestion (8). Minimize cost. Minimize life cycle cost including initial capital outlay, operation cost, maintenance cost, and salvage (4). Minimize waste. Storage facility should not increase waste volume (2). Minimize space requirements. Storage should not use a lot of site space (Dropped). Availability. Storage must be available (15).	Sea-Land containers. Store miscellaneous items in Sea-Land containers located north of the existing chemical plant buildings. Construct a new storage building. Use an existing chemical plant building.	Miscellaneous items are currently being stored in Sea-Land containers. More containers can be purchased to expand storage capacity. Sea-Land containers do not increase waste volume, because they can be decontaminated and released. High cost. Requires a lot of site space. Minimizes use of site space. Provides efficient storage for miscellaneous items. Increases waste volume. Makes use of an existing building. Building not available. High cost to decontaminate and repair building.	Continue to use Sea-Land containers for storage of misc. items. If more storage is needed, the existing gravel pad on which existing containers are supported can be expanded and more can be purchased. When containers are no longer needed, they should be unloaded, decontaminated, and released from the site.

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TABLE 5.1.8-6 Results of Modified Value Engineering: Dust Control

Evaluation Criteria (Weight from MVE)	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Dependability. Dust control system must be available and operable when needed (9). Minimize cost. Minimize life cycle cost (Dropped). Minimize maintenance. Minimize maintenance in contaminated areas (4). Minimize hand labor. Hand labor should be minimized in contaminated areas. Mobility. Dust control system should be easily moved from one area to another. Maximize coverage. Dust control system should be able to cover large areas.	Water trucks. Fixed sprinklers. Movable sprinklers.	Maximizes the area that can be covered. Standard methods of past control. Dependable. Requires no hand labor in contaminated areas. Cost may be higher because of labor and fuel. Low cost. Not dependable. High maintenance. Small coverage area. Not dependable. High maintenance. Requires hand labor in contaminated areas.	Water trucks.

TABLE 5.1.8-7 Results of Modified Value Engineering: Training Facilities

Evaluation Criteria (Weight from MVE)	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Convenient location. The training facility should be located at or near the WSS (2). Uncongested location. The training facility should be located in an area that will not interfere with other site activities (8). Minimize cost. Minimize life cycle cost including initial capital outlay, operation cost, and maintenance cost (Dropped). Availability. The facility should be available for 8 yr (6). Timeliness. The facility needs to be available soon.	Build a new training facility on-site. Buy or lease space. Expand existing trailer.	Provide a convenient location. Could be built in an uncongested area north of the PMC parking lot. Could have negative public perception. If space is found, it could probably be converted quickly to a training facility. Somewhat inconvenient. May be hard to find space in the Weldon Spring area. Space is not available for expansion of the existing space. Low cost.	A search for available off-site space should be conducted. If off-site space is available, a new facility should be constructed on site.

TABLE 5.1.8-8 Distribution of Contaminated Water - Sequence 1

Sequence 1 - Foundation Removal and Phase I of Clean Fill Dike (CFD) Construction, Construct Retention Ponds 1, 2 and 3							
Source of Contaminated Water	a Estimated Volume of Contaminated Water from Previous Years (mg)	b ** Annual Precip. Runoff Volume (mg)	c *** 25 Yr Design Storm Volume (mg)	d=a+b+c Volume of Total Water (mg)	Volume of Water Treated In Sequence 1 (mg)	Volume of Water Not Treated in Sequence 1 (mg)	Proposed Retention Facility for Storage of Untreated Water
RP 1	1.30	0	0.03	1.33	0.99	*0.34	RP 1
RP 3	7.70	0	0.25	7.95	5.46	*2.49	RP 3
RP 2	1.30	0	0.04	1.34	1.00	*0.34	RP 2
RP 4	32.89	0	0.44	33.33	28.95	*4.38	RP 4
Ash Pond Area	0	3.66	0.33	3.99	3.99		
TSA	2.20	9.80	Included	12.00	12.00		
MSA	2.22	8.80	in b	11.02	11.02		
CP Area	1.33	3.99	Included	5.82	5.82		
Excavation	0	0	in b				
DC Phase I	0	0	0.50				
DC Phase II	0	0	0				
DC Phase III	0	6.56	0	6.96	0.32	6.64	RP 4, Retention Ponds 1, 2 and 3
25% Contingency			0 0.40				
Total	48.94	32.81	1.99	83.74	69.55	14.19	

* Minimum volume required to maintain radon barrier and float cutter head dredge.
** Assume evaporation from pond surface area is equal to precipitation on pond surface area.
*** Retention Ponds 1, 2 and 3 will provide short term retention for design storm runoff.

- Design treatment capacity of SWTP Train 1 = 39.74 mg/yr.
- Design treatment capacity of SWTP Train 2 = 19.87 mg/yr.
- Design treatment capacity of the MWTP = 9.94 mg/yr.
- Total design treatment volume = 69.55 mg/yr.
- Assume WTPs are available for operation 345 d/yr, 24 hrs/d.
- (mg) = million gallons

TABLE 5.1.8-9 Distribution of Contaminated Water - Sequence 2

Sequence 2 - CFD Phase II Complete, Dredging R.P.'s 2 and 4, Begin Dredging in Raffinate Pits 1 and 3							
Source of Contaminated Water	a Estimated Volume of Contaminated Water from Previous Years (mg)	b ** Annual Precip. Runoff Volume (mg)	c *** 25 Yr Design Storm Volume (mg)	d=a+b+c Volume of Total Water (mg)	Volume of Water Treated in Sequence 2 (mg)	Volume of Water not Treated in Sequence 2 (mg)	Proposed Retention Facility for Storage of Untreated Water
Volume Carried Forward from Previous Year	14.19			14.19	6.84		
RP 1		0	0.03	0.03	0.03	*0.34	RP 1
RP 3		0	0.25	0.25	0.26	*2.49	RP 3
RP 2		0	.04	0.04	0.04	*0.34	RP 2
RP 4		0	0.44	0.44	0.44	*4.38	RP 4
Ash Pond Area		3.56	0.33	3.99	3.99		
TSA		9.80	Included in b	9.80	9.80		
MSA		8.80		8.80	6.80		
CP Area		0	Included in b	0			
Excavation		5.07		7.37	7.37		
DC Phase I		0	0				
DC Phase II		0	2.30				
DC Phase III		6.83	0	7.68	7.68		
25% Contingency			0.85				
Total	14.19	34.16	4.24	52.59	45.04	7.55	

* Minimum volume required to maintain radon barrier and float cutter head dredge.
** Assume evaporation from pond surface area is equal to precipitation on pond surface area.
*** Retention Ponds 1, 2 and 3 will provide short term retention for design storm runoff.

- Design treatment capacity of SWTP Train 1 = 39.74 mg/yr.
- Design treatment capacity of SWTP Train 2 = 19.87 mg/yr.
- Design treatment capacity of the MWTP = 9.94 mg/yr.
- Total design treatment volume = 69.55 mg/yr.
- Assume WTPs are available for operation 345 d/yr, 24 hrs/d.
- (mg) = million gallons

TABLE 5.1.8-10 Distribution of Contaminated Water - Sequence 3

Sequence 3 - Cover Complete on Phase I of Cell, Dredging Complete in Raffinate Pits 2 and 4, Dredging Continues in Raffinate Pits 1 and 3							
Source of Contaminated Water	a Estimated Volume of Contaminated Water from Previous Years (mg)	b ** Annual Precip. Runoff Volume (mg)	c *** 25 Yr Storm Volume (mg)	d=a+b+c Volume of Total Water (mg)	Volume of Water Treated in Sequence 3 (mg)	Volume of Water not Treated in Sequence 3 (mg)	Proposed Retention Facility for Storage of Untreated Water
Volume Carried Forward from Previous Year	7.55			7.55	4.72		
RP 1		0	0.03	0.03	0.03	*0.34	RP 1
RP 3		0	0.25	0.25	0.25	*2.49	RP 3
RP 2		0	0.04	0.04	0.04		
RP 4		0	0.44	0.44	0.44		
Ash Pond Area		3.66	0.33	3.99	3.99		
TSA		9.80	Included	9.80	9.80		
MSA		8.80	in b	8.80	8.80		
CP Area		0	Included	0			
Excavation		13.64	in b	15.94	15.94		
DC Phase I		6.12	0	7.15	7.15		
DC Phase II		0	2.30	0			
DC Phase III		10.51	1.03	11.62	11.62		
25% Contingency			1.11				
Total	7.55	52.53	5.53	65.61	62.78	2.83	

* Minimum volume required to maintain radon barrier and float cutter head dredge.
** Assume evaporation from pond surface area is equal to precipitation on pond surface area.
*** Retention Ponds 1, 2 and 3 will provide short term retention for design storm runoff.

- Design treatment capacity of SWTP Train 1 = 39.74 mg/yr.
- Design treatment capacity of SWTP Train 2 = 19.87 mg/yr.
- Design treatment capacity of the MWTP = 9.94 mg/yr.
- Total design treatment volume = 69.55 mg/yr.
- Assume WTPs are available for operation 345 d/yr, 24 hr/d.
- (mg) = million gallons

TABLE 5.1.8-11 Distribution of Contaminated Water - Sequence 4

Sequence 4 - CFD Phase III Construction, Dredging Complete in Raffinate Pits 1 and 3, MSA, TSA, and Ash Pond Removed							
	a	b	c	d=a+b+c			
Source of Contaminated Water	Estimated Volume of Contaminated Water from Previous Years (mg)	** Annual Precip. Runoff Volume (mg)	*** 25 Yr Design Storm Volume (mg)	Volume of Total Water (mg)	Volume of Water Treated in Sequence 4 (mg)	Volume of Water not Treated in Sequence 4 (mg)	Proposed Retention Facility for Storage of Untreated Water
Volume Carried Forward From Previous Year	2.83			2.83	2.83		
RP 1			0.03	0.03	0.03		
RP 3			0.25	0.25	0.25		
RP 2							
RP 4							
Ash Pond Area							
TSA							
MSA							
CP Area		13.64	2.30	15.94	15.94		
Excavation		6.12	1.30	7.42	7.42		
DC Phase I		6.79	1.14	7.93	7.93		
DC Phase II		6.64	1.26	7.90	7.90		
DC Phase III							
25% Contingency							
Total	2.83	33.19	6.78	42.30	42.30		

* Minimum volume required to maintain radon barrier and float cutter head dredge.
** Assume evaporation from pond surface area is equal to precipitation on pond surface area.
*** Retention Ponds 1, 2 and 3 will provide short term retention for design storm runoff.

- Design treatment capacity of SWTP Train 1 = 39.74 mg/yr.
- Design treatment capacity of SWTP Train 2 = 19.87 mg/yr.
- Design treatment capacity of the MWTP = 9.94 mg/yr.
- Total design treatment volume = 69.55 mg/yr.
- Assume WTPs are available for operation 345 d/yr, 24 hr/d.
- (mg) = million gallons

TABLE 5.1.8-12 Distribution of Contaminated Water - Sequence 5

Sequence 5 - Phase III Waste Placement							
Source of Contaminated Water	a Estimated Volume of Contaminated Water from Previous Years (mg)	b ** Annual Precip. Runoff Volume (mg)	c *** 25 Yr Design Storm Volume (mg)	d=a+b+c Volume of Total Water (mg)	Volume of Water Treated in Sequence 5 (mg)	Volume of Water not Treated in Sequence 5 (mg)	Proposed Retention Facility for Storage of Untreated Waste
Volume Carried Forward From Previous Year	0			0			
RP 1							
RP 3							
RP 2							
RP 4							
Ash Pond Area							
TSA							
MSA							
CP Area Excavation							
DC Phase I		6.12	1.03	7.15	7.15		
DC Phase II		6.79	1.14	7.93	7.93		
DC Phase III		3.73	0.54	4.27	4.27		
25% Contingency							
Total	0	16.64	2.71	19.35	19.35		

* Minimum volume required to maintain radon barrier and float cutter head dredge.
** Assume evaporation from pond surface area is equal to precipitation on pond surface area.
*** Retention Ponds 1, 2 and 3 will provide short term retention for design storm runoff.

- Design treatment capacity of SWTP Train 1 = 39.74 mg/yr.
- Design treatment capacity of SWTP Train 2 = 19.87 mg/yr.
- Design treatment capacity of the MWTP = 9.94 mg/yr.
- Total design treatment volume = 69.55 mg/yr.
- Assume WTPs are available for operation 345 d/yr, 24 hr/d.
- (mg) = million gallons

TABLE 5.1.8-13 Distribution of Contaminated Water - Sequence 6

Sequence 6 - Cell Complete, Storm Runoff Retention Ponds Removed							
Source of Contaminated Water	a Estimated Volume of Contaminated Water from Previous Years (mg)	b ** Annual Precip. Runoff Volume (mg)**	c *** 25 Yr Design Storm Volume (mg)	d=a+b+c Volume of Total Water (mg)	Volume of Water Treated in Sequence 6 (mg)	Volume of Water not Treated in Sequence 6 (mg)	Proposed Retention Facility for Storage of Untreated Water
Volume Carried Over From Previous Year	0			0			
RP 1							
RP 3							
RP 2							
RP 4							
Ash Pond Area							
TSA							
MSA							
CP Area							
Excavation							
DC Phase I		6.79	1.14	7.93	7.93		
DC Phase II		1.70	0.29	1.99	1.99		
DC Phase III							
25% Contingency							
Total	0	8.49	1.43	9.22	9.92		

* Minimum volume required to maintain radon barrier and float cutter head dredge.
** Assume evaporation from pond surface area is equal to precipitation on pond surface area.
*** Retention Ponds 1, 2 and 3 will provide short term retention for design storm runoff.

- Design treatment capacity of SWTP Train 1 = 39.74 mg/yr.
- Design treatment capacity of SWTP Train 2 = 19.87 mg/yr.
- Design treatment capacity of the MWTP = 9.94 mg/yr.
- Total design treatment volume = 69.55 mg/yr.
- Assume WTPs are available for operation 345 d/yr, 24 hr/d.
- (mg) = million gallons

TABLE 5.1.8-14 Summary of Contaminated Water Balance

Year	a Volume of Water Carried Over From Previous Year (mg)	b Volume of Average Annual Precipitation (mg)	c Volume of 25 Yr Design Storm Runoff (mg)	d=a+b+c Total Volume of Contaminated Water (mg)	e Total Volume of Water Treated (mg)	f=d-e (mg)
1	48.94	32.81	1.99	83.74	69.55	14.19
2	14.19	34.16	4.24	52.59	45.04	7.55
3	7.55	52.53	5.53	65.61	62.78	2.83
4	2.83	33.19	6.28	42.30	47.30	0
5	0	16.64	2.17	19.35	19.35	0
6	0	8.49	1.43	9.92	9.92	0

mg million gallons

TABLE 5.2.1-1 Disposal Facility System Components

Disposal Cell Components	Design Features	Governing Criteria
Top Cover System – Vegetated Cover	Vegetation provides long-term erosion resistance and self-healing capability. Allow evaporation and transpiration of infiltrating moisture. A rooting zone that also serves as protection for the radon/infiltration barrier. This zone also stores moisture until it can be evaporated or transpired by the vegetation. A filter layer that prevents piping of rooting media soil into the underlying biointrusion barrier. Also provides thickness for frost protection. A biointrusion barrier consisting of coarse gravel that discourages burrowing animals, provides frost protection, acts as a capillary break for the upward migration of moisture, and provides rapid lateral drainage if the upper rooting zone becomes saturated. A bedding layer to cushion the biointrusion barrier material from the geomembrane. A geomembrane to prevent the infiltration of moisture into the disposal cell and to provide the same degree of transmissivity as the liner system. A compacted clay radon and infiltration barrier that acts as the liner system. A compacted clay radon and infiltration barrier that acts with the geomembrane to form a composite liner to reduce infiltration, and provides sufficient thickness to attenuate the radon.	Minimize the amount of infiltration entering the waste. Reduce the radon flux through the cover to ALARA. Protect the waste from human, animal, and biological intrusion. Prevent erosion and instability of the disposal cell. Provide a cover with a permeability of at least as low as the lowest permeability element of the liner.
Clean-Fill Dikes	Rock erosion layer provides protection from surface water runoff on the steeper side slope. Filter/bedding layer prevents plucking of the underlying clean-fill dike material by interstitial flows in the rock erosion barrier. Clean-fill dike allows for deep root penetration of vegetation growing on the rock erosion layer, without penetrating the waste. Dike configuration isolates the waste from the outer slopes of the disposal cell, decreasing the potential for instability affecting the waste. Allows for increased infiltration through the rock cover, without contacting the waste. Provides massive zone that decreases radon releases.	Enhance stability of the disposal cell. Protect the disposal cell from erosion due to natural forces. Protect the waste from intrusion by humans, animals and plants. Reduce the radioactive hazard of the waste to ALARA. Reduce the potential of seepage exiting the sides of the disposal cell. Allow for deep rooting of plants in the surface riprap. Minimize the potential for differential settlement of the cover.

TABLE 5.2.1-1 Disposal Facility System Components (Continued) 030994

Disposal Cell Components	Design Features	Governing Criteria
Waste	Use of CSS or VIT treatment of selected wastes allows a stable cover to be constructed. Use of CSS- or VIT-treated materials to encapsulate and fill voids of demolition debris. CSS or VIT treatment retards movement of the hazardous constituents within the wastes for the disposal cell design life. Homogeneous placement of debris minimizes differential settlement. Zonation of material provided in case infiltrating water is encountered.	Minimize differential settlement and/or subsidence of the cover. Minimize the potential for leachate generation due to the exposure of waste to percolating water or vadose zone moisture flux. Provide pathways for moisture to move downward through the waste due to gravity.
Liner and Leachate Collection and Removal System	Leachate collection and removal system collects water infiltrating during construction and after closure of the cell. Allows monitoring of cover tightness and leachate generation. Geomembrane prevents leachate from exiting the cell and in combination with the underlying clay liner, minimizes the potential for leaks. Tracer allows "signature" if leaks occur so that they can be detected in the vadose zone monitoring system. Clay liner retards the migration of leachate and provides geochemical attenuation of contaminants. Vadose zone monitoring system provides leak detection. Access tubes for VMS provide secondary leachate collection.	Collect the leachate generated during construction and after cell completion until leachate is no longer generated. Retard the movement of leachate out of the disposal cell. Prevent the movement of leachate from the disposal cell for as long as practicable by means of the FML components. Attenuate the hazardous constituents in leachate.
Disposal Cell Foundation	Although not technically part of the disposal cell, the foundation provides additional benefits for system performance. The upper layer (3 ft to 5 ft) may be recompacted to provide a low permeability foundation and to uniformly repair damage cause by the site cleanup. Including recompacted soil layer, a total of at least 30 ft of 10^{-7} cm/s soil lies between the base of the cell and the uppermost aquifer. A vadose zone monitoring system is placed in the foundation to monitor changes in moisture and quality if vadose flux below the cell. The 30 ft of clay or its equivalent will act as a geochemical barrier to attenuate contaminants that might exit the bottom of the disposal cell.	Provide an equivalent of 30 ft of low permeability soil under the disposal cell having an average hydraulic conductivity of less than 10^{-7} cm/s, and at least 20 ft of undisturbed natural soil. Provide a zone for a vadose zone monitoring system.

TABLE 5.2.1-2 On-Site Disposal Options

On Site Disposal Option	Description	Advantages	Disadvantages
Lagoons.	A dike containment system holding a waste slurry without treatment.	Particularly suitable for containing raffinate sludges.	Poor ability of waste to support a cover system. Will not meet RCRA or UMTRA standards for waste disposal. Potential for atmospheric contamination and intruder exposure.
Waste piles.	Non-containerized accumulation of waste at ground level but including a bottom liner.	The bottom liner prevents leachate from exiting the piles.	Does not minimize leachate generation. Will not meet RCRA or UMTRA standards. Poses a long-term threat to the environment and intruders.
Landfills.	Sanitary landfills, considered here to have a liner and minimal cap system, but non-engineered waste placement; and direct burial landfills with only minimal cover.	Sanitary landfills have the same components as a hazardous waste cell, but because the waste is less hazardous, feature redundancy and lack robustness.	For the purposes under consideration, it is assumed that landfill cap is not sufficient to contain hazardous waste or radioactive by-product waste.
Vaults.	Similar to an engineered cell, but waste is contained in a reinforced concrete or steel structure.	Provides a incremental improvement against contaminant migration and intruder exposure if liner systems are included, compared to an engineered disposal cell.	Require longer design and construction schedules than an engineered cell. Difficult to accommodate waste quantity variation. Material placement is difficult due to the vault shape. Costly, compared to an engineered disposal cell.
Cap/cover systems.	Ancillary requirement for an in situ treated waste.	Provide protection from intruders, infiltration and exposure to the waste.	Building debris and other rubble will still require disposal. Provide inadequate protection of the surrounding soil or groundwater, should leachate migrate from the treated material.

TABLE 5.2.1-2 On-Site Disposal Options (Continued)

On Site Disposal Option	Description	Advantages	Disadvantages
Engineered cells.	Consist of a multi-layered cap, carefully placed and compacted waste, and a bottom liner and leachate collection and removal system.	Flexible - can be designed to accommodate all waste types found at Weldon Spring. Provide long-term waste storage to protect the groundwater and to prevent intrusion.	Costlier than all other options, except vaults.

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TABLE 5.2.2-1 Results of Modified Value Engineering: Cell Siting

Evaluation Criteria (Weight from MVE)	List Alternatives (Final Ranking)	Advantages/Disadvantages	Preferred Alternative
Number of Cells, CSS and VIT Cases (Ref. 122)			
Performance (34): Surface water control, slope stability, settlement, erosion protection, infiltration. Minimize worker radiation and chemical exposure (26): Reduce construction worker exposure to radiological (ALARA) and chemical contaminants from the disposed waste. Not OSHA. Ability to adjust cell capacity (15): Flexibility and opportunity for changing design and construction to accommodate changes in volumes, forms, and characteristics of waste materials. Constructability (14): Optimize water control, public impact, traffic patterns, duration, pollution control, and construction methodology. Minimize volume of construction materials required (12): Balance cut and fill and minimize construction material quantities. Utilization of waste material (11): Optimize usage in disposal cell features and minimize volume of waste material.	Single Cell: 1 All wastes, including rubble, will be in one cell.	**Advantages:** Minimizes volume of construction materials. Maximizes flexibility for cell capacity to adjust to waste volume changes in the limited area available. Simplifies construction, surveillance, maintenance, and surface water control. Reduces number of cells being opened concurrently. Easy to design. **Disadvantages:** Increases worker radiation and chemical exposure. Increases potential for differential settlement. Reduces flexibility for expansion of cell	Single cell.

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TABLE 5.2.2-1 Results of Modified Value Engineering: Cell Siting (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Ranking]	Advantages/Disadvantages	Preferred Alternative
Minimize surveillance and maintenance required (10). Construction sequencing (7): Potential to adjust construction sequencing to accommodate other site activities. Aesthetics (7): Public perception, overall height and appearance. Simplicity of design (6): Minimize design complexity.				
	Two cells: One cell for CSS or VIT material; second cell for all other materials.	2	**Advantages:** Allows separate designs for separate waste types. Easier to use different base elevations to best use existing topography. Reduces worker radiation and chemical exposure. Allows more sequencing flexibility than one cell. **Disadvantages:** Requires more construction materials. Requires more complex design especially regarding surface water control features. Requires more surveillance and maintenance. Increases flow concentration between cells, increased area of infiltration.	
	More than two cells: One cell for each specific waste type or form.	3	**Advantages:** Essentially same as two cell alternative. **Disadvantages:** Disadvantages magnified over those of two cell alternative. May have interference in sequencing.	

TABLE 5.2.2-2 Observational Method: Cell Siting

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
1. Number of Cells, CSS and VIT Cases				
Single Cell.	All wastes, including CSS or VIT waste, and rubble will be placed in one cell.	Locations of designated cleanup areas, and horizontal and vertical extents of contaminated soils. Hence, the total volume of waste to be disposed of.	Low.	Cell capacity and time for cell closure.

TABLE 5.2.2-3 Data Quality Objectives: Cell Siting

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
1. Number of Cells, CSS and VIT Cases			
Locations of designated cleanup areas, and horizontal and vertical extents of contaminated soils. Hence, the total volume of waste to be disposed of.	Cell capacity and waste placement procedures must be designed flexible enough to accommodate additional waste.	What space will be available for disposal of additional wastes?	Need all required data to well define the total volume of waste to be disposed of.

TABLE 5.2.3-1 Results of Modified Value Engineering: Cell Configuration/Optimization

Evaluation Criteria (Weight from MVE)	List Alternatives (Final Ranking)	Advantages/Disadvantages	Preferred Alternative
1. Cell configuration (Ref. 122)			
Enhance slope stability (23). Reduce settlement (23). Reduce infiltration (14). Cell capacity flexibility (14): Flexibility and opportunity for changing design and construction to accommodate changes in volumes, forms, and characteristics of waste materials. Minimize volume of construction materials (9): Balance cut and fill and minimize construction material quantities. Simplicity of design and construction (8): Minimize design and construction complexity. Aesthetics (6): Public perception, overall height, and appearance.	Excavate below grade: 1 Start as deep as possible, if the cell is underlain by a minimum thickness of 20 ft of naturally occurring materials with an equivalent permeability of 30 ft of soil with permeability of 10^{-7} cm/sec.	**Advantages:** Increases storage capacity for a given area; reduce volume of construction materials required and enhance performance; e.g., slope stability, settlement behavior, and erosion resistance. Excavation produces material some of which can be used in construction. Reduces cell height resulting in reduced visual impact. **Disadvantages:** Closer to groundwater table but does not preclude meeting state regulations for separation from aquifer. More complex design and construction due to liner, dewatering, access. Above are minor disadvantages compared to resulting benefits.	Excavate below grade.
	Allow base plane of disposal cell to deviate from being parallel to site topography. 2	**Advantages:** Similar to increasing depth of excavation, to a lesser extent. Greater design and construction flexibility. Leachate collection system can be more thoroughly optimized. Overall site drainage more readily optimized. More flexibility in meeting requirement for buffer zone above water table by cut and fill. **Disadvantages:** Similar to increasing depth of excavation.	

TABLE 5.2.3-1 Results of Modified Value Engineering: Cell Configuration/Optimization (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	(Final Ranking)	Advantages/Disadvantages	Preferred Alternative
	Increase cell area within suitability area limit.	3	**Advantages:** Reduces cell height, and reduces settlement, increases stability, decreases visual impact, and lessens energy use. Allows more flexibility for volume adjustments during construction. **Disadvantages:** Increases infiltration. Increases construction materials. Increases potential for complex geometry; i.e., more corners. Increases land use.	

TABLE 5.2.3-1 Results of Modified Value Engineering: Cell Configuration/Optimization (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Ranking]	Advantages/Disadvantages	Preferred Alternative
2. Perimeter Encapsulation System (Ref. 53)			
Cell performance (21): reduces settlement, increase slope stability, and reduce radon flux. Increase erosional resistance (19): Maximize long-term erosional resistance. Increase the recurrence interval of precipitation causing erosion. Minimize potential for gully initiation. Provide for longer P(f) <1.0 period after cessation of maintenance of vegetation, and cell. [P(f) = Probability of Failure]. Facilitate leachate control (15): groundwater protection, reduce footprint, reduce infiltration, facilitate internal drainage layout, facilitate outside of cell observation and control. Worker radiation and chemical exposure (12): Reduce construction worker exposure to radiological (ALARA) and chemical contaminants from the disposed waste. Not OSHA. Public perception (9): Cell robustness, aesthetics, reduce height, waste isolation, visceral evaluation, gut reaction. Minimize maintenance (7): During the period of active institutional control, reduce the cost and need for cover repair and vegetation maintenance.	Clean-fill dike (CFD) 1 The perimeter encapsulation system for the disposal cell will be a perimeter dike, constructed using compacted uncontaminated soil and rock prior to the placement of the contaminated material.	**Advantages:** Yields good overall performance (stability, erosion, settlement, and robustness). Reduces worker exposure. Provides additional safety margin against damage from differential settlements. Provides a wide buffer between the cell surface and the contaminated material. **Disadvantages:** Requires a bigger demand for improved borrow material and possibly a longer construction time. Increases footprint area resulting in increased cover area.	Clean-fill dike.
	No clean-fill dike (NFD). 2	**Advantages:** Requires smaller footprint area resulting in reduced cover area. Requires less construction materials than CFD. **Disadvantages:** Possible reduced performance (slope stability along synthetic liner in cover). Greater worker exposure.	

TABLE 5.2.3-2 Summary of Waste Storage Volume, Waste Thickness, Cell Thickness, and CFD Volume

Cell Type	Cell Configuration	Waste Storage Volume (million cu yd)	Waste Thickness (ft)	Total Cell Thickness[a] (ft)	CFD Volume (million cu yd)
CSS	Minimum excavation	1.55	26	42	1.60
	Partially below grade	1.55	22/28[b]	38/44[b]	1.00
VIT	Minimum excavation	1.05	26	42	1.32
	Partially below grade	1.05	22/28[b]	38/44[b]	0.78

(a) Total cell thickness is equal to the sum of a 9.5-ft-thick cell cover, the waste, and a 6.5-ft-thick basal liner and leachate collection system.

(b) Due to a step foundation for the partially below grade cell configuration, the thickness left of the slash refers to the thickness on the eastern half of the cell, whereas the thickness right of the slash refers to the thickness on the western half of the cell.

TABLE 5.2.3-3 Observational Method: Cell Configuration Optimization

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
1. Cell Configuration				
Below grade excavation.	The cell is underlain by a minimum thickness of 20 ft of naturally occurring materials consisting of Ferrelview clay and clay till which retard contaminants in a manner equivalent to that of 30 ft of soil with a permeability of 10^{-7} cm/sec.	Part of the footprint area may not meet the minimum 20-ft thickness requirement.	Low	Modify footprint, i.e., reduce footprint area or move cell footprint until the minimum thickness requirement is met. Reduce depth of excavation in area where the minimum thickness requirement is not met. Remove and replace or amend soils in order to lower the soil permeability in area where the minimum thickness requirement is not met.

TABLE 5.2.3-4 Data Quality Objectives: Cell Configuration Optimization

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
1. Cell Configuration			
Part of the footprint area may not meet the minimum 20-ft thickness requirement.	Will have to reduce the footprint area.	Will reducing the footprint area result in increasing the cell height? Will the new cell have enough room to store all wastes?	Need topographic map, substrata isopach contour maps, and the new cell configuration.
	Will have to move the footprint area to a new suitable location.	Should we study other possible alternatives?	Need topographic map, substrata isopach maps, and boundary of new areas being studied.
	Will have to remove and replace or amend soils in order to reduce the soil permeability.	Will the replaced or amended soil layer be considered as part of the naturally occurring material?	Need laboratory and in situ soil permeability test data.

TABLE 5.2.4-1 Results of Modified Value Engineering: Cell Foundation Design

Evaluation Criteria (Weight from MVE)	List Alternatives (Final Ranking)	Advantages/Disadvantages	Preferred Alternative
Cell Foundation Design Ref. 39			
Protect groundwater (13). Comply with regulations (10): Meet Federal and State design requirements, in particular, the 20 ft equivalency requirement (State's Clause III). Support cell (9): Provide foundation stability, minimize settlement. Demonstrate performance (5): Facilitate and expedite characterization, analysis, testing and modelling in the design process and demonstrate to technical peers the performance and integrity of system. Facilitate surveillance and maintenance (3): Facilitate monitoring and measurement of long-term cell/foundation/groundwater performance and protection. Facilitate contingency repair of cell or groundwater restoration. Natural process replication (3): Maximize use of beneficial natural process and work together with natural system.	Remove and replace. 1 Remove part or all of materials and replace with selected (and possibly sequenced) engineered layers. Note: Excavation of contaminated material and foundation/utilities is required for all five alternatives.	**Advantages:** Easiest to demonstrate performance by controlling engineered material properties. Complies with the State's Clause III regulation. **Disadvantages:** Requires more complex foundation and leachate collection system designs and construction. Requires extensive field and laboratory data. Has significant environmental impacts due to borrow material requirements. Expensive.	Remove and replace.
	Remove and amend. 1 Remove part or all of the materials, add, admixture to improve the physical properties or chemistry and replace.	**Advantages:** Easiest to demonstrate performance by controlling engineered material properties. Complies with the State's Clause III regulation. **Disadvantage:** May encounter difficulties in mixing different materials. More expensive than remove and replace.	

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TABLE 5.2.4-1 Results of Modified Value Engineering: Cell Foundation Design (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives (Final Ranking)	Advantages/Disadvantages	Preferred Alternative
	Raise grade. 2 Place additional material to increase the thickness of foundation materials, and thereby the distance to groundwater table, or decrease the overall equivalent permeability of basal layers	**Advantages:** Complies with the State's Clause II or III regulations. Simpler design and construction of the disposal cell including the liner and leachate collection system are simpler. **Disadvantage:** Very expensive to construct due to large volume of additional material.	
	At grade. Place cell foundation at existing ground level with minimum grading operations. 3	**Advantages:** Complies with the State's Clause III regulation. Design and construction of the disposal cell including the liner and leachate collection system are easier. **Disadvantages:** Difficult to demonstrate performance.	
	In situ stabilization. 4 Inject, mix into, pump into existing material, grout chemical or other liquid/solid in order to improve permeability, strength, and chemistry.	**Advantages:** Design and construction of the disposal cell including the liner and leachate collection system are easier. **Disadvantages:** Difficult to demonstrate performance. May encounter difficulties in mixing different materials.	

TABLE 5.2.5-1 Results of Modified Value Engineering: Liner System and LCRS

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Short-term performance - Contain and collect leachate during non-equilibrium flow conditions period. Allow monitoring of leachate quality and quantity. Long-term performance - Allow equilibrium leachate flow to exit bottom of the cell or provide an alternative. (Equilibrium flow is steady-state flow equal to the cover flux). Monitor vadose zone moisture content and quality prior to leachate leaving cell. Provide added attenuation of leachate constituents. Provide added specific retention (storativity) for leachate.	No liner, no LCRS.	**Advantages:** Minimizes potential for long-term need to collect leachate. No maintenance or monitoring required. Lowest cost. **Disadvantages:** Unable to collect construction or transient drainage. Provides no additional protection of groundwater. Relies solely on other features for groundwater protection. No redundancy.	Double liner with two LCRSs.
Provide redundancy for each functioning component of the leachate collection-liner system. Be cost effective, providing additional protection or operational assurance for the added cost. Minimize the need for maintenance of the liner system and minimize the requirement for monitoring.	Single liner without LCRS.	**Advantages:** Low cost. Briefly retards migration of leachate. Maintenance and monitoring are minimized. **Disadvantages:** May cause "bathtub effect". Only very short-term protection of the groundwater. No redundancy. Must rely on other features if liner breach occurs. Cost/benefit ratio is poor.	

TABLE 5.2.5-1 Results of Modified Value Engineering: Liner System and LCRS (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Single liner with LCRS.	**Advantages:** Good short-term performance. Minimizes potential for the bathtub effect. Good to very good long-term performance. Cost/benefit ratio is good. **Disadvantages:** Does not provide redundancy of individual elements in the liner/LCRS. Does not allow detection of leaks in the primary liner prior to leachate exiting the lowermost liner. Difficult to maintain or repair.	
	Double liner with two LCRSs.	**Advantages:** Very good short-term performance. Very good long-term performance. Allows detection of leaks in the primary liner before leachate exits the liner system. Provides redundancy of all elements of the liner/leachate collection system. Most cost effective. Eliminates uncontrolled exit of leachate from the disposal cell. Redundancy reduces the potential need for repairs if failure of the primary liner and/or LCRS occurs. **Disadvantages:** Requires additional maintenance and monitoring. Difficult to impossible to repair.	

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TABLE 5.2.5-1 Results of Modified Value Engineering: Liner System and LCRS (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	More than two liners, more than two LCRSs.	**Advantages:** Maximizes the potential to restrict movement of leachate out of the bottom of the cell. Excellent short-term and long-term performance. Maximum redundancy of features. **Disadvantages:** Not cost effective. Little is gained through additional redundancy. Requires the most maintenance and monitoring. Difficult to impossible to repair.	

TABLE 5.2.5-2 Observational Method: Liner System and LCRS

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
Double liner with two LCRSs.	Non-equilibrium leachate is generated and collected for 30 yr to 50 yr. Leachate flow then reaches equilibrium with cover flux.	Leachate generation period is shorter.	Medium	None.
		Leachate generation period is longer.	Medium	LCRS has ability to function for well over 50 yr. There is increased reliance on redundant LCRS. Attenuation of leachate may be accomplished by any natural clay components of the liner system. The collection and treatment period is extended.
	Liner and LCRS function until non-equilibrium leachate is no longer generated.	Liners fail before LCRS.	Low	None. The LCRS will function with reduced effectiveness. Attenuation of leachate constituents is still provided by the foundation soils.
		LCRS fails before liner.	Low	If a portion of the LCRS fails, adjacent areas of the LCRS will provide redundancy after some head buildup. If the entire LCRS fails, the liner will continue to contain leachate and separate it from the groundwater.
	Cover minimizes infiltration.	Cover does not minimize infiltration.	Low	None. LCRS will continue to collect leachate.

TABLE 5.2.5-2 Observational Method: Liner System and LCRS (Continued)

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
	Flows from the LCRS are small, decreasing with time.	Flows are larger than anticipated.	Low	A safety factor is provided for flows in excess of those considered reasonable. If flows exceed even these rates, a head will build up and force flow from the LCRS. Response measures can be initiated to determine the cause and remediate the problem.
	LCRS collects leachate and precipitation inflows during the construction period.	Primary liner fails during construction.	Low	The redundant LCRS will detect the liner failure and will collect leachate and precipitation flows until remedial measures can be taken.

TABLE 5.2.5-3 Results of Modified Value Engineering: Liner Components and Configurations

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Prevent leachate from entering liner. Prevent leachate from exiting bottom of liner. Short-term performance (0 yr to 50 yr). Long-term performance (>50 yr). Chemical compatibility with leachate. Minimum volume.	FML.	**Advantages:** FML alone is excellent at preventing leachate from entering the liner. Short-term performance is very good. Chemical compatibility is also very good. **Disadvantages:** Poor at preventing leachate from exiting the bottom of the liner after entering liner. Long-term performance is unknown, but assumed marginal at best.	Preferred alternatives are FML/CCL/FML, FML/GCL/CCL, and FML/GCL/FML with all three scoring essentially equal. However, they appear to be over-conservative with their redundant components. FML/CCL and FML/GCL are also considered to be acceptable preferred alternative. As a result, FML/CCL and FML/GCL are both selected as equal preferred alternatives based upon cost/benefit ratio. Use FML/GCL for primary liner to minimize volume occupied within the disposal facility.
	FML/CCL (compacted clay liner) composite liner.	**Advantages:** Excellent at preventing leachate from entering the liner. Excellent chemical compatibility with leachate plus attenuation. Good short-term and long-term performance. Good at preventing leachate from exiting the bottom of the liner. **Disadvantages:** Not all leachate can be prevented from exiting the bottom of the liner. Long-term performance is less than short-term due to uncertain FML design life.	

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TABLE 5.2.5-3 Results of Modified Value Engineering: Liner Components and Configurations (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	FML/GCL (geosynthetic clay liner) composite liner.	**Advantages:** Excellent at preventing leachate from entering liner. Excellent short-term performance. Excellent chemical compatibility with leachate. **Disadvantages:** Long-term performance is hampered due to thin liner. Leachate has only a short distance to travel before it can exit the liner.	
	CCL.	**Advantages:** Very good at preventing leachate from exiting the bottom of the liner. Very good long-term performance and chemical compatibility with leachate plus attenuation capability. Short-term performance is less than optimum but satisfactory. **Disadvantages:** Marginal at preventing leachate from entering the liner.	
	GCL.	**Advantages:** Good chemical compatibility with leachate. Satisfactory short-term performance. **Disadvantages:** Poor at preventing leachate from entering liner. Marginal long-term performance. Marginal at preventing leachate from exiting bottom of the liner. Overlap/seaming technique.	

TABLE 5.2.5-3 Results of Modified Value Engineering: Liner Components and Configurations (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	FML/GCL/FML composite liner.	**Advantages:** Excellent at preventing leachate from entering or exiting the liner. Excellent chemical compatibility and short-term performance. **Disadvantages:** FMLs will degrade over the longer term.	
	FML/GCL/CCL composite liner.	**Advantages:** Excellent at preventing leachate from entering or exiting the liner. Excellent short- and long-term performance. Good chemical compatibility plus attenuation. **Disadvantages:** FML portion will degrade with time.	
	Gravel.	**Advantages:** Good long-term performance. Very good chemical compatibility. **Disadvantages:** Poor at preventing leachate from entering or exiting liner. Poor short-term performance.	
	FML/CCL/FML composite liner.	**Advantages:** Excellent at preventing leachate from entering or exiting the liner. Excellent short-term performance and chemical compatibility plus attenuation. **Disadvantages:** FML will degrade with time.	

TABLE 5.2.5-3 Results of Modified Value Engineering: Liner Components and Configurations (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Bitumen (asphalt).	**Advantages:** Good at preventing leachate from entering the liner. Very good short-term performance. Good chemical compatibility with the leachate. **Disadvantages:** Marginal at preventing leachate from exiting the bottom of the liner. Poor long-term performance.	
	Portland cement concrete.	**Advantages:** Excellent short-term performance. Moderate chemical capability with leachate. **Disadvantages:** Marginal at preventing leachate from entering or exiting liner. Marginal long-term performance.	
	Epoxy sealant.	**Advantages:** Excellent at preventing leachate from entering liner. Excellent short-term performance. Satisfactory chemical compatibility with leachate. **Disadvantages:** Poor at preventing leachate from exiting bottom of liner. Poor long-term performance.	
	No liner.	**Advantages:** Chemical compatibility problems nonexistent. **Disadvantages:** Poor short-term performance. Does not prevent leachate from entering or exiting liner.	

TABLE 5.2.5-3 Results of Modified Value Engineering: Liner Components and Configurations (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Grouted soil.	**Advantages:** Good chemical compatibility. Fair short-term performance. **Disadvantages:** Marginal to poor prevention of leachate from entering liner and long-term performance. Poor at preventing leachate from exiting bottom of liner.	
	Chemically amended soil.	**Advantages:** Good chemical compatibility. Fair short-term performance. **Disadvantages:** Marginal to poor at preventing leachate from entering liner and long-term performance. Poor at preventing leachate from exiting the bottom of the liner.	
	Steel plates.	**Advantages:** Excellent short-term performance. Excellent at preventing leachate from entering liner. Very good chemical compatibility with leachate. Good long-term performance. **Disadvantages:** Poor at preventing leachate from exiting bottom of liner.	

TABLE 5.2.5-4 Observational Method: Liner Components and Configurations

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
FML/GCL for primary liner. FML/CCL for secondary liner.	Leachate is generated in significant quantities over the short-term (approximately 50 yr).	Leachate is not generated in significant quantities over the short-term.	Medium	No adverse effect. Design ends up being more conservative.
	Leachate generation rate drops significantly to a steady long-term rate after about year 50.	Leachate generation rate does not drop significantly after about 50 yr.	Medium	FMLs may or may not be functioning effectively. However, the clay components of the liners will continue to perform satisfactorily. The GCL component of the primary liner will probably invade the redundant LCRS drainage layer. However, the LCRS will continue to function, as will the redundant LCRS to a limited extent.
	Actual leachate is accurately represented in the liner compatibility tests ongoing as part of Supporting Study No. 25.	Actual leachate is more aggressive than that used in testing.	Low	An extreme case would be total degradation of FMLs and increased permeability in the compacted clay and geosynthetic clay liners.
		Actual leachate is less aggressive than that used in testing.	Medium	No adverse effect. Design conservatism is enhanced.
	FML will degrade to an ineffective state after about 50 yr.	FML will degrade to an ineffective state before 50 yr.	Low	Compacted clay and geosynthetic clay liners will continue to function. As noted above, the LCRSs will also continue to perform well.
		FML will not degrade to an ineffective state after about 50 yr.	Medium	No adverse effect. Design conservatism is enhanced.

TABLE 5.2.5-4 Observational Method: Liner Components and Configurations (Continued)

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
	Disposal cell foundation settlements may result in significant settlements in the liners.	No significant settlements in the liners.	Low	As the settlement magnitude decreases, the risk of damage to or failure of the FMLs and GCLs decreases. Therefore, safety factors increase.
		Settlements are excessively large.	Low	Large settlements will damage the FMLs and may cause failure of the relatively thin GCLs. However, the thick compacted clay component of the secondary liner is expected to prevent total liner failure.
	Disposal cell is filled to capacity.	Excess space is available within the cell.	Medium low	GCL was chosen as the natural component of the primary liner to conserve cell capacity. If cell capacity is not a concern, a CCL could be used. CCL also has additional attenuating properties.

TABLE 5.2.5-5 Data Quality Objectives: Liner Components and Configurations

List of Potential Deviations	Does Potential Deviation Effect Design?	Specific Questions to be Answered	Data Collection Activities
Leachate is not generated in significant quantities over the short-term.	No		
Leachate generation rate does not drop significantly after about 50 yr.	Yes	Determine the estimated leachate flow rates over time.	Supporting Study No. 45B.
Actual leachate is more aggressive than that used in testing.	Yes	Perform liner compatibility tests using a truly representative leachate. Also, is the leachate calcium-rich, thereby posing a risk of increasing the permeability of the clay soils?	Currently being performed as part of Supporting Study No. 25.
Actual leachate is less aggressive than that used in testing.	No		
FML will degrade to an ineffective state before 50 yr.	No		
FML will not degrade to an ineffective state before 50 yr.	No		
No significant settlements in the liners.	No		
Liner settlements are excessively large.	No		

TABLE 5.2.5-6 Results of Modified Value Engineering: FML Material Type

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
ALARA permeability. Maximum longevity (extrapolated). Tensile strength to withstand stresses due to downdrag of waste and self-weight. Chemical resistance to withstand chemical attack by leachate.	Smooth high density polyethylene (HDPE).	**Advantages:** Excellent chemical resistance. Reasonable longevity. Testable seams. Low permeability. Adequate tensile strength. Inexpensive. **Disadvantages:** Potential stress cracking. Complex seaming method. Poor friction. Thermal expansion/contraction. Poor puncture resistance.	Textured VLDPE scored highest. However, the final selection is dependent upon the results of the liner compatibility testing, which is ongoing. As results become available, alternatives may be eliminated.
Quality seaming method that is easy, testable, and reliable. Weathering resistance to withstand UV degradation, oxidation, and extreme temperatures.	Textured HDPE.	**Advantages:** Same as for smooth HDPE plus excellent friction. **Disadvantages:** Same as for smooth HDPE excluding friction.	
Friction between FML and adjacent material to enhance side slope stability. Puncture resistance.	Polyvinyl chloride (PVC).	**Advantages:** Easy to seam. High quality seams. Inexpensive. Good tensile strength. Low permeability. Good puncture resistance. **Disadvantages:** Less than optimum chemical resistance. Moderate longevity due to poor weathering resistance and oxidation when exposed. Poor friction.	

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TABLE 5.2.5-6 Results of Modified Value Engineering: FML Material Type (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Chlorosulfonated polyethylene (CSPE).	**Advantages:** Very good chemical resistance at moderate temperature. Good longevity. Good tensile strength. Easy to seam. High quality seams. Low permeability. Excellent weathering resistance. Excellent resistance to thermal expansion/contraction. **Disadvantages:** Poor friction. Probably most expensive option. Performance degrades in high temperature environments. Fair puncture resistance. Blocking (or stickiness) occurs under high temperatures.	
	Smooth very-low-density Polyethylene (VLDPE).	**Advantages:** Same as smooth HDPE but has excellent elongation and puncture resistance. **Disadvantages:** Same as smooth HDPE excluding puncture resistance. Has somewhat reduced chemical resistance compared to HDPE.	
	Textured VLDPE.	**Advantages:** Same as smooth VLDPE plus excellent friction. **Disadvantages:** Same as smooth VLDPE excluding friction.	

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TABLE 5.2.5-7 Observational Method: FML Material Type

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
Textured VLDPE is the preliminary choice. However, final selection is dependent upon the results of the Liner Compatibility Tests (Supporting Study 26).	Actual leachate is accurately represented by liner compatibility test leachate.	Actual leachate under operating conditions is more aggressive than anticipated.	Low	Although there is reasonably high confidence in the chemical resistance of the FML, an extreme effect could be total degradation.
		Actual leachate is less aggressive than anticipated.	Medium	None. Safety factor is increased.
	FML will not be exposed to high temperatures.	FML is exposed to high temperatures.	Low	Blocking and possible degradation occur in CSPE.
	Proper construction methods and QA will be implemented, including subgrade preparation and FML protection.	Improper construction, protection, or preparation methods.	Medium low	Effectiveness of FML design will be largely negated if proper methods are not utilized.
	FML longevity is accurately represented by accelerated testing and extrapolated data.	FML longevity is significantly less than expected.	Medium	Accelerated tests and extrapolated design life are the only available means of predicting FML longevity. If longevity is less than anticipated, the FML will not be functional throughout its design life. A possible solution is to increase the thickness of the FML.

TABLE 5.2.5-8 Results of Modified Value Engineering: Natural Material Liners

Evaluation Criteria (Weight from MVE)	List Alternatives(Final Ranking)	Advantages/Disadvantages	Preferred Alternative
Cost and Ease of Construction (2): Minimize the time and effort, thus cost in installing the liner. Permeability (14): Characteristic of the liner to serve as a low-permeability hydraulic barrier. Mechanical Compatibility (8): Ability to maintain its integrity during and after exposure to short-term and long-term mechanical stresses. Chemical Compatibility (16): Physical and engineering properties of the liner remain essentially unchanged after exposure to leachate or waste materials. Ductility (12): Flexibility or ability to prevent cracking from desiccation, foundation settlement or interaction with leachate or waste materials. Ease of Obtaining Agreements with Government Agencies (23): Regulatory Compliance - Federal, State, or City Government design requirements.	Compacted clay liner (CCL): A hydraulic barrier constructed by compacting low-permeability materials (essentially clayey materials) to 2 ft to 4 ft in thickness. 1	**Advantages:** Too thick to puncture. Large leachate-attenuation capacity that can function as geochemical barrier. Relatively long containment time. Agreements with government agencies easily obtained. Easily accepted by public. Possible utilization of on-site soils if below-grade disposal facility option is chosen. **Disadvantages:** Thickness takes up space. Constructed with heavy equipment. Slow construction. Cost is highly variable. Requires selected borrow sources. Site-specific data on soils needed. Often requires test pad. Relatively difficult to build uniformly. Subject to potential cracking due to movement, or drying and wetting.	Compacted Clay Liner (CCL).

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TABLE 5.2.5-8 Results of Modified Value Engineering: Natural Material Liners (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives[Final Ranking]	Advantages/Disadvantages	Preferred Alternative
Geochemical barrier (4): Liner may function as an absorption medium to attenuate or retard the spread of chemical contaminant, in addition to its basic function as a hydraulic barrier. Public perception (12): Public acceptance of the liner design, including material type and method of placement.	Geosynthetic clay liner (GCL): 3 A manufactured liner consisting of a thin layer of clay sandwiched between two geotextiles or glued to a geomembrane. Currently manufactured GCL products include: Bentofix®, Bentomat®, Claymax®, and Gundseal®.	**Advantages:** Thin: little space is taken. Light construction equipment can be used. Much faster construction. More predictable cost. Manufactured product: Data available (quality control) (No borrow area needed). Easy to build. Relatively low permeability. Some self-healing effect if cracking occurs prior to saturation. **Disadvantages:** Possible to be damaged and punctured. Small leachate-attenuation capacity. Shorter containment time. Difficult to obtain agreements with government agencies. Difficult to be accepted by public. Bentonite may react more adversely with leachate than regular clayey soils.	

TABLE 5.2.5-8 Results of Modified Value Engineering: Natural Material Liners (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives[Final Ranking]		Advantages/Disadvantages	Preferred Alternative
	Compacted bentonite amended soil liner: A hydraulic barrier constructed by compacting soil mixed with appropriate proportion of bentonite to 2 ft to 4 ft in thickness.	2	**Advantages:** Too thick to puncture. Relatively large leachate-attenuation capacity. Long containment time. Relatively easy to obtain agreements with government agencies. Relatively easy to be accepted by public. **Disadvantages:** Large thickness takes up space. Constructed with heavy equipment. Slow construction. Cost is highly variable and is most likely very expensive. Site specific data on soils needed. Test pad is required. Very difficult to build uniformly. Dust control is required during mixing process. Bentonite may react more adversely with leachate than regular clayey soils.	

TABLE 5.2.5-9 Observational Method: Liner

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
Compacted clay liner (CCL).	Composite liner functions properly throughout the design life.	FML fails before clay liner.	Medium	Attenuation of leachate accomplished by clay liner.
		Clay liner fails before FML.	Low	Increase reliance on redundant LCRS, if a double-liner system is adopted. Attenuation of leachate accomplished by foundation soils, if a single-liner system is adopted.
		Both FML and clay liner fail.	Very Low	Increase reliance on both LCRS and redundant LCRS. Attenuation of leachate accomplished by foundation soils.
Combination of geonet on the cell side slopes and granular material on the bottom.	Leachate can flow through the waste down to the bottom of the cell. If the side slope LCRS drain material is unable to carry leachate flow, the leachate will still be able to migrate down to the bottom of the cell.	Leachate is unable to move through the waste down to the cell bottom. After degradation of the side slope drain layer, the leachate encounters the side slope liner and begins to pond. The ponded leachate is unable to migrate downward through the waste to the bottom LCRS drain layer.	Low	The effect of ponding within the waste would create the undesirable bathtub effect that may lead to leachate seeping through the clean fill dikes. Such a scenario would totally eliminate the need for a LCRS on even the bottom of the cell because the leachate could never migrate down to it. However, selective waste placement may help prevent such an occurrence.
	Leachate characteristics are not conducive to biological growth or chemical precipitation.	Leachate promotes biological growth or chemical precipitation.	Low	Biological growth and chemical precipitation can create clogging of the drain layers and materials.

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TABLE 5.2.5-9 Observational Method: Liner (Continued)

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Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
	Cell side slopes below grade are steeper than 3(H):1(V).	Cell side slopes below grade are flatter than 3(H):1(V).	Medium low	No adverse effect. However, flatter side slopes would alter the MVE scoring to make granular material on both the side slopes and bottom the preferred alternative.
	Vitrified waste product is not available in sufficient quantities and will be produced periodically throughout operation of the cell.	Vitrified waste products is available in sufficient quantities and will be produced early enough in the construction/operation stages to be used in the drain layer.	Low	Availability of vitrified waste product may make it the preferred alternative in place of granular material.

Notes: LCRS: Leachate collection and removal system

TABLE 5.2.5-10 Results of Modified Value Engineering: LCRS Drain Material

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Chemical compatibility with waste/leachate. Ability to withstand chemical attack, degradation, and clogging. Function as desired and meet design permeability requirements. Require no maintenance. Constructible with conventional construction methods.	Geonet.	**Advantages:** Reasonable cost. Easily installed on cell bottom and steep side slopes. HDPE resin resists chemical degradation. Meets transmissivity requirements. Readily available. Requires no maintenance during its design life. **Disadvantages:** Unproven and unknown longevity. Even the extrapolated design life is less than 500 yr. Requires a filter layer.	Combination of geonet on the cell side slopes and granular material on the bottom. Side slopes are defined as the excavation sidewalls in a below-grade disposal cell or the interior slopes of a perimeter clean-fill dike.
Longevity. Cost. Available in sufficient quantities.	Vitrified waste product.	**Advantages:** Cost is minimal if vitrification treatment option is chosen. Probably has adequate longevity. Easily installed on cell bottom. Compatible with waste and leachate. Can be processed to meet all functional requirements. Requires no maintenance. **Disadvantages:** Material is unavailable if the vitrification treatment option is not selected. May not be available in sufficient quantities even if chosen. Granular nature of material makes installation on side slopes difficult; a minimum side slope of 3(H) to 1(V) is probably required. May require a filter layer.	

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TABLE 5.2.5-10 Results of Modified Value Engineering: LCRS Drain Material (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Granular material (sand or gravel).	**Advantages:** Reasonable cost. Easily installed on cell bottom. Proven longevity. Compatible with waste/leachate. Can meet all functional requirements. Requires no maintenance. Readily available. **Disadvantages:** Difficult to install on cell side slopes; a minimum side slope of 3(H) to 1(V) is probably required. May require a filter layer.	
	Combination of geonet on the cell side slopes and granular material on the cell bottom. Side slopes are defined as the excavation sidewalls in a below-grade disposal cell or the interior slopes of a perimeter clean-fill dike.	**Advantages:** Reasonable cost. Easily installed on both cell side slopes and bottom. Compatible with waste/leachate. Meets all functional requirements. Requires no maintenance. Readily available. The LCRS on the cell bottom will continue to function even after the geonet on the side slopes degrades. **Disadvantages:** Geonet has unproven longevity. Requires a filter layer at least over the geonet and possibly over the granular material.	

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TABLE 5.2.5-11 Results of Modified Value Engineering: LCRS Filter Material

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Provide filter function. Chemically and physically compatible with the waste and leachate. Longevity equivalent to or greater than the longevity of the drain material. Constructibility with conventional methods. Cost.	Geotextile.	**Advantages:** Good filtering ability. Resistant to chemical degradation. Easy to install. Reasonable cost. **Disadvantages:** Unproven longevity and, in any case, less longevity than granular drain materials. May require special protection from UV light during installation/operation.	Geotextile over geonet drain material and graded sand and gravel over granular drain material.
	Graded sand and gravel.	**Advantages:** Good filtering ability. Very resistant to chemical attack. Proven longevity. Easy to install on cell bottom. Reasonable cost. **Disadvantages:** Difficult to install on cell side slopes. Filter material will clog a geonet drain material.	
	Geotextile over geonet drain material on the cell side slopes and graded sand and gravel over granular drain material on the cell bottom.	**Advantages:** Good filtering ability. Resistant to chemical attack. Proven longevity for granular filter material over granular drain material. Longevity of geotextile filter material is probably comparable to longevity of geonet drain layer. Easy to install. Reasonable cost. **Disadvantages:** None identified.	

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TABLE 5.2.5-12 Results of Modified Value Engineering: LCRS Conveyance System Material

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Adequate flow capacity to drain leachate at least as fast as the drainage layer can produce it. Resistance to biological, chemical, and physical clogging, plugging, or silting. Adequate load bearing strength to withstand the large stresses induced by the overlying waste and construction equipment.	Perforated HDPE pipe.	**Advantages:** Good flow capacity. Deforms under loads. Resistant to chemical attack. Easy to connect and install. **Disadvantages:** Round perforations can become plugged by bedding gravel. No proven longevity. Moderate strength.	Slotted HDPE pipe inside of rock drain.
Resistance to brittle failure. Ability to deform rather than fail totally and suddenly. • Longevity.	Slotted HDPE pipe.	**Advantages:** Same as for perforated HDPE pipe plus less susceptible to clogging or plugging. **Disadvantages:** Same as for perforated HDPE pipe excluding plugging susceptibility.	
Chemical compatibility to withstand chemical attack by leachate. • Ease of installation and reliability of connections, especially considering settlement-induced tensile stresses in pipes.	Perforated PVC pipe.	**Advantages:** Good flow capacity. Resistant to chemical attack. Easy to install and connect. **Disadvantages:** Round perforations can be plugged by bedding gravel. Has a brittle failure mode. No proven longevity.	
	Slotted PVC pipe.	**Advantages:** Same as for perforated PVC pipe plus less susceptible to clogging or plugging. **Disadvantages:** Same as for perforated PVC pipe excluding plugging susceptibility.	

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TABLE 5.2.5-12 Results of Modified Value Engineering: LCRS Conveyance System Material (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Stainless steel slotted well screen.	**Advantages:** Good flow capacity. Strong. Resists chemical attack. Resists plugging and clogging. **Disadvantages:** Very expensive. Difficult to install and connect. Can behave as a brittle material. Longevity unproven.	
	Vitrified clay pipe.	**Advantages:** Good flow capacity. Long proven design life. Relatively safe from chemical attack. **Disadvantages:** Perforations can be plugged by bedding gravel. Not especially strong. Very brittle. Difficult if not impossible to connect securely.	
	Reinforced concrete pipe.	**Advantages:** Good flow capacity. Strong. Relatively safe from chemical attack. **Disadvantages:** Unproven design life. Brittle failure. Difficult if not impossible to connect securely.	
	Rock drain.	**Advantages:** Very strong. Non-brittle. Proven longevity. Resists chemical attack. Easy to install. **Disadvantages:** Difficult to obtain flow capacities for design flows. Small pore spaces are very susceptible to clogging. Almost impossible to clean or unclog.	

TABLE 5.2.5-12 Results of Modified Value Engineering: LCRS Conveyance System Material (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Pipe inside of rock drain.	**Advantages:** Same advantages as pipe type is used. When pipe eventually fails, rock drain continues to provide preferential drainage path. **Disadvantages:** Small pore spaces in rock drain portion are still susceptible to clogging.	

TABLE 5.2.5-13 Results of Modified Value Engineering: LCRS Holding System

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Resist chemical degradation by leachate. Prevent escape of leachate through leaks and overflow. Allow gravity inflow and gravity overflow. Allow access for maintenance, repair, and replacement. Prevent inflows of precipitation to minimize volume to be treated. Permit means of leak detection.	HDPE sumps.	**Advantages:** Excellent chemical resistance. Minimal risk of leakage. Gravity inflow and overflow feasible. Can be assessed for maintenance, repair, and replacement. Prevents precipitation inflow. Can be double-lined for leak detection capabilities. **Disadvantages:** Detection of leaks past the double-liner is difficult because the sump is below grade. If design leachate volume is high, the holding capacity may be inadequate.	If design holding volume is small, use HDPE sumps. If design holding volume is large, use covered and lined retention ponds/basins.
	Lined concrete sumps.	**Advantages:** Gravity inflow and overflow feasible. Accessible for maintenance, repair, and replacement. Prevents precipitation inflow. Can be sized for large leachate volume. **Disadvantages:** Detection of leaks is difficult. Double-lining may be difficult. Concrete may develop cracks providing avenues for escape. May be susceptible to chemical attack.	

TABLE 5.2.5-13 Results of Modified Value Engineering: LCRS Holding System (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Covered and lined retention ponds/basins.	**Advantages:** Excellent chemical resistance. Minimal risk of leakage. Gravity inflow and overflow feasible. Accessible for maintenance, repair, and replacement. Prevents most precipitation inflow. Can use a double-lined system for leak detection. Virtually unlimited capacity. **Disadvantages:** Holes in the cover may go undetected for a period, allowing precipitation to seep in. Susceptibility of cover to vandalism, damage, degradation, and deterioration. Difficult to detect leaks if ponds are below grade and not double-lined with a leak detection system.	
	Lined open retention ponds/basins.	**Advantages:** Excellent chemical resistance. Leaks through the bottom minimized. Gravity inflow and overflow. Accessible for maintenance, repair, and replacement. Virtually unlimited capacity. **Disadvantages:** Catches all precipitation. Allows evaporation of leachate water and volatile constituents, thereby altering leachate concentration. May pose threat to waterflow. Loss of control over inflows and outflows makes detection of leaks more difficult. Difficult to detect leaks if ponds are below grade and not double-lined with a leak detection system.	

TABLE 5.2.5-13 Results of Modified Value Engineering: LCRS Holding System (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Above-ground tanks.	**Advantages:** Excellent chemical resistance. Minimizes risk of leaks. Accessible for maintenance, repair, and replacement. Prevents precipitation inflow. Leaks easily detected. Permits gravity overflow. **Disadvantages:** Gravity inflow is very difficult.	

TABLE 5.2.5-14 Results of Modified Value Engineering: LCRS Sump Location

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Minimize or avoid penetrating the final cover to prevent radon pathway out and water pathway in. Provide holding capacity for leachate volumes which may be quite large until long-term, steady-state conditions are reached. Provide for gravity flow out of the cell and gravity overflow. Allow maintenance and repair. Avoid ponding greater than 1 ft depth on the bottom liner.	Sump inside cell with vertical pipe access (manholes).	**Advantages:** Adequate storage volume. Provides access for maintenance and repair. **Disadvantages:** Penetrates the cover. Difficult if not impossible to meet requirement for gravity flow out of cell and gravity overflow capability. May allow ponding on the bottom liner.	Sump outside of cell.
	Sump outside of cell.	**Advantages:** Adequate storage volume. Easily repaired, maintained, or replaced. No ponding on liner. No cover penetration. Leachate exits cell by gravity and can accommodate gravity overflow features. **Disadvantages:** More bottom liner penetrations. However, if cover is intact, leachate generation is minimized. Suitable location outside of cell is required.	
	Gravel holding zone within cell accessed via inclined pipes.	**Advantages:** No cover penetration. No bottom liner penetration. **Disadvantages:** Questionable storage capacity. Impossible to replace or repair. Forces ponding on the bottom liner. Does not permit gravity drainage from cell or gravity overflow provisions.	

TABLE 5.2.5-14 Results of Modified Value Engineering: LCRS Sump Location (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Minimize or avoid penetrating the final cover to prevent radon pathway out and water pathway in. Provide holding capacity for leachate volumes which may be quite large until long-term, steady-state conditions are reached. Provide for gravity flow out of the cell and gravity overflow.	Sump inside cell with vertical pipe access (manholes).	**Advantages:** Adequate storage volume. Provides access for maintenance and repair. **Disadvantages:** Penetrates the cover. Difficult if not impossible to meet requirement for gravity flow out of cell and gravity overflow capability. May allow ponding on the bottom liner.	Sump outside of cell.
	Sump inside cell with inclined pipe access.	**Advantages:** No cover penetration. No bottom liner penetration. Adequate storage capacity. **Disadvantages:** Impossible to replace or repair. May allow ponding on the bottom liner. Does not permit gravity drainage from cell or gravity overflow provisions.	

TABLE 5.2.5-15 Observational Method: LCRS Drain Material

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
Combination of geonet on the cell side slopes and granular material on the bottom.	Leachate can flow through the waste down to the bottom of the cell. If the side slope LCRS drain material is unable to carry leachate flow, the leachate will still be able to migrate down to the bottom of the cell.	Leachate is unable to move through the waste down to the cell bottom. After degradation of the side slope drain layer, the leachate encounters the side slope liner and begins to pond. The ponded leachate is unable to migrate downward through the waste to the bottom LCRS drain layer.	Low	The effect of ponding within the waste would create the undesirable bathtub effect that may lead to leachate seeping through the clean fill dikes. Such a scenario would totally eliminate the need for a LCRS on the bottom of the cell because the leachate could never migrate down to it. However, selective waste placement may help prevent such an occurrence.
	Leachate characteristics are not conducive to biological growth or chemical precipitation.	Leachate promotes biological growth or chemical precipitation.	Low	Biological growth and chemical precipitation can create clogging of the drain layers and materials.
	Cell side slopes below grade are steeper than 3(H):1(V).	Cell side slopes below grade are flatter than 3(H):1(V).	Medium low	No adverse effect. However, flatter side slopes would alter the MVE scoring to make granular material on both the side slopes and bottom the preferred alternative.
	Vitrified waste product is not available in sufficient quantities and will be produced periodically throughout operation of the cell.	Vitrified waste products is available in sufficient quantities and will be produced early enough in the construction/operation stages to be used in the drain layer.	Low	Availability of vitrified waste product may make it the preferred alternative in place of granular material.

TABLE 5.2.5-16 Observational Method: LCRS Filter Material

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
Geotextile over geonet drain material and graded sand and gravel over granular drain material.	Filter material, especially the geotextile, will be protected from sharp, protruding, or otherwise damaging waste by placing a select waste layer between the filter and the general waste.	Select waste layer is not placed adjacent to the filter to provide protection from sharp, protruding, or otherwise damaging waste.	Medium low	Damage to the filter layer will allow the drain layer to become clogged and functionally impaired.

TABLE 5.2.5-17 Observational Method: LCRS Conveyance System Material

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
Slotted HDPE pipe inside of rock drain.	Leachate is relatively non-aggressive and does not attack HDPE or rock.	Leachate is more aggressive than anticipated.	Low	Ability of the materials to drain the leachate would be compromised.
	Pipe component will function effectively during the high-flow, short-term conditions.	Pipe component fails prematurely.	Low	Rock drain serves as a redundant feature. Flow capacity is reduced but not eliminated. Leachate can still be carried throughout the long term.

TABLE 5.2.5-18 Observational Method: LCRS Holding System

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
HDPE sumps, if design holding volume is small. Covered and lined retention ponds/basins, if design holding volume is large.	System will be monitored and maintained.	System will not be monitored and maintained.	Low	Monitoring is essential to proper leachate collection and removal. All potential designs require monitoring.
	No undetected leaks.	System deteriorates and undetected leaks occur.	Low	Requires a leak detection system and removal plan to monitor and remove leachate.

TABLE 5.2.5-19 Observational Method: LCRS Sump Location

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrance	Effect on Design
Sump outside of cell.	Long-term monitoring and collection of leachate is required.	Long-term monitoring and collection of leachate is not required.	Medium	None.

TABLE 5.2.6-1 Results of Modified Value Engineering: Waste Placement

Evaluation Criteria (Weight from MVE)	List Alternatives	(Final Rating)	Advantages/Disadvantages	Preferred Alternative
1. General Guidelines for Placement of Waste				
Minimize settlement (13.1): Reduce the amount of total and differential settlement that could result in cover cracking, flow concentration, ponding, infiltration. Worker exposure (7.7): Reduce construction worker exposure to radiological (ALARA) and chemical contaminants. Distinct from OSHA.	Place debris randomly, interspersed with CSS, VIT, and soil, tending to develop homogeneity. Place metal and fill voids with CSS, VIT, or clean grout. Last phase would be mostly soil.	1	**Advantages:** Tendency to randomness will provide least differential settlement. Easily adapts to whatever waste form is available. Good flexibility of construction operation. Can handle many variations in rate of waste flow with no adverse effects. **Disadvantages:** None.	Place debris randomly.
Construction considerations (6.3): Facilitate void filling; simplify access road layout; simplify schedule; reduce phase complexity; provide flexibility to accommodate future changes in waste quantity and form. Simplify construction.	Place metal and fill voids with CSS, VIT, or clean grout. Then place concrete rubble and fill voids with CSS (grout or soil-like), VIT, and /or soil. Place CSS/VIT. Place soil.	3	**Advantages:** Similar to above option. May allow for earliest removal of MSA. **Disadvantages:** Main disadvantage is potential for increased differential settlement due to stronger zonation of waste forms in cell.	
Material removal/supply/availability/ placement/accommodation (5.4): Microzonation needs met; reduce complex demands on CSS/VIT plant. Facilitate accommodation of random and varying supply of waste. Stockpile/rehandle (4.0): Minimize need to stockpile, rehandle waste. Reduce required MSA area. Early removal of MSA desirable.	Place debris across bottom of cell and fill voids with CSS, VIT, grout, or soil. Fill voids in metal waste with CSS, VIT, or clean grout. Use remaining waste over rubble.	2	**Advantages:** Similar to first option above. **Disadvantages:** Quantities and delivery rates of metal waste may make this option difficult.	

TABLE 5.2.6-1 Results of Modified Value Engineering: Waste Placement (Continued)

Evaluation Criteria [Weight from MVE]	List Alternatives [Final Rating]		Advantages/Disadvantages	Preferred Alternative
Cell internal drainage (0): Provide a pathway for water infiltrating cover, and transient drainage to move to leachate collection system without potentially seeping from perimeter encapsulation, or from ponding (bathtub effect).	Place metal with soil-like CSS and leave open voids in metal. Place construction rubble. Place soil.	drop	**Advantages:** Doesn't require grouting operation. **Disadvantages:** Weakest on long-term cell integrity and settlement control. Requires special measures to convert sludges into soil-like CSS.	
2. Construction of Cell in Two or Three Phases				
Worker Exposure (17.0). Integrity of cell (17.0). Time to complete disposal cell (0.0): Work may be delayed waiting for liner construction, phase preparation. Total volume flexibility (6.0): Will design allow for enough flexibility to accommodate whatever volume contingency is needed.	Two phases. Construct Phase II LCRS during Phase I waste placement. MSA area will probably be in Phase II area.	1	**Advantages:** Only mobilize for liner and LCRS operation two times. Fewer phase-related construction joints in liner, and hence, less cleanup required to get past seams. Larger working area for waste placement. **Disadvantages:** Not quite as flexible for total volume contingency.	Two-phase alternative is slightly preferable from a waste placement perspective, but other considerations (e.g., waste excavation, balancing cut/fill or clean-fill dikes; an increased concern regarding contingency capacity will change the weighting for the MVE evaluation) may sway this. The three-phase alternative will also work well.
Accommodate available waste forms (5.0): Have space to place whatever waste is available without delaying operations. Large working area (3.0): Allow room for placement of several waste forms simultaneously. Large enough to allow CSS grout to set before requiring next lift be placed.	Three phases. Similar to above option, but sequence repeated once more.	2	**Advantages:** Most flexible for total volume contingency. Will not need to prepare such a large area all at once. **Disadvantages:** More joints where liner construction stopped and must resume after construction; could create problem areas. More joints means more clean-up to get past joints. Slightly smaller working area.	

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TABLE 5.2.6-1 Results of Modified Value Engineering: Waste Placement (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	(Final Rating)	Advantages/Disadvantages	Preferred Alternative
3. Microphases Versus Two or Three Phases				
Worker exposure (15.0). Integrity of cell (14.0). Runoff minimization (2.0). Accommodate available waste schedule (5.0). Ease of construction (1.0). Total volume flexibility (3.0).	Use microphases, with active area of waste placement as small as possible.	2	**Advantages:** Most flexible with total volume contingency. Minimizes contaminated runoff from cell. **Disadvantages:** Smaller active area makes operations more cramped. May segregate wastes (from phase to phase), which could increase differential settlement. More jointing. Need to keep separage crews and equipment around at all times.	Two- or three-phase approach is preferred. Based on scheduling MVE (Ref. 58), waste will have a temporary cover (i.e., the first lifts of the radon barrier) by the time winter comes (except after the first half of Phase I, which <u>needs</u> to be large for CSS placement), so reducing contaminated runoff is not imperative.
	Use two or three phases for cell construction as well as waste placement operations.	1	**Advantages:** Large working area. Best ability to make waste thicknesses homogeneous to minimize differential settlement. Three-phase approach has nearly as much volume flexibility as microphases. **Disadvantages:** Two-phase approach is not quite so flexible with total volume, but using a small "closure phase" could improve on this. Two- or three-phase approach appears best, but the microphase alternative should be studied further during the CDR work.	

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TABLE 5.2.6-2 Observational Method: Waste Placement

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
1. General Guidelines for Placement of Waste				
Place debris randomly, tending to homogeneously intersperse with CSS and soil. Place metal concrete rubble and fill voids with CSS. Last phase would be largely soil.	All metal will be in MSA at start of job.	Metal may not yet all be in MSA at start of job.	Low to Medium (?)	None. When metal becomes available, grout will need to be produced to entomb it. Production timing of grout-like CSS is flexible. Could buy clean grout.
	There is enough raffinate to produce the volume of grout-like CSS required to fill the voids in all metal and concrete wastes.	There may not be enough raffinate to produce the volume of grout-like CSS required to entomb all metal and concrete wastes.	Low	Could vary recipe to make more grout (Ref. 52) gives several acceptable grout recipes). Could buy clean grout.
	Leachate quantities and contamination levels will be low after leachate from rainfall during cell construction has subsided.	Steady state leachate flow rate and/or contamination levels may be higher than expected.	Low	May need to account for or design preferential drainage paths within waste.
2. Construction of Cell In Two or Three Phases				
Use a two-phase cell with a closure phase.	Contingency will reduced soon enough to confidently estimate cell volume during Phase I waste placement and to establish final cell footprint.	Actual waste volume may exceed estimate when closure phase is constructed.	Low	Allow for increase in cell height to accommodate extra volume.
		Actual waste volume may be less than estimated when closure phase is constructed.	Medium	Allow for decrease in cell height to match actual volume.

TABLE 5.2.6–2 Observational Method: Waste Placement (Continued)

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
3. Microphase Versus Two or Three Phases				
Use two or three phases.	Will be able to handle contaminated runoff from area of active phase.	May not have large enough water treatment capacity.	Low	Increase interim storage capacity, provide greater water treatment plant capacity, or switch to microzones.
		CSS may set slowly enough to restrict rate of rise of waste surface.	Low	Probably no change, but could consider possibility of changing to microzones, or use accelerators in CSS mix.

TABLE 5.2.6–3 Data Quality Objectives: Waste Placement for Radon Control

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
1. General Guidelines for Placement of Waste			
Metal may not all be in MSA at start of job.	No	None	None
There may not be enough raffinate to produce enough grout-like CSS to entomb all metal and concrete wastes.	Yes	How much grout will be available and on what schedule?	Compare viable CSS recipes with available quantities of raffinate and soil to be treated.
Steady state leachate flow rate and/or contamination levels may be higher than expected.	Yes	What is predicted rate and quality of leachate.	Evaluate cover and waste permeability, including potential effect of preferential drainage paths within waste. Evaluate potential for contaminants from the waste to be transported by leachate.
2. Construction of Cell in 2 or 3 Phases			
Actual waste volume may exceed estimate when closure phase is constructed.	Yes	What is the maximum likely and maximum possible waste? What probabilities are associated with these?	Evaluate extent of contaminated soil requiring clean-up beneath raffinate pits.
Actual waste volume may be less than estimated when closure phase is constructed.	Yes	What is the minimum likely and minimum possible waste? What probabilities are associated with these?	
4. Microphase Versus Two or Three Phases			
May not have sufficient water treatment capacity.	Yes	Will interim storage and site WTPs have capacity for contaminated runoff from cell?	Evaluate capacity of interim storage and WTPs. Design runoff from cell.

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TABLE 5.2.6-3 Data Quality Objectives: Waste Placement for Radon Control (Continued)

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
CSS may set at rate which will restrict rate of rise of waste surface.	Yes	How soon can CSS be driven on and how soon can it be covered with a subsequent lift?	Assess rate of strength gain of CSS with time. Time required before CSS can support appropriate rubber-tired equipment.

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TABLE 5.2.6-4 Results of Modified Value Engineering: Waste Placement for Radon Control

Evaluation Criteria (Weight from MVE)	List Alternatives	(Final Rating)	Advantages/Disadvantages	Preferred Alternative
1. Zonation Control of Radioactive Waste				
Worker safety (9.0). Integrity of cell (10.0). Environmental Protection (10.0). Accommodation of available waste schedule (2.0). Ease of construction (0.0).	Place waste randomly, without regard for level of radioactivity.	1	**Advantages:** Easier construction, accommodates available waste schedule much better. **Disadvantages:** Slightly less redundancy of environmental protection. Slightly greater worker exposure. May require slightly thicker radon barrier.	Place waste randomly. Where convenient, route the more radioactive waste away from the cover, but only when significant effort is not required. When future radon studies have been completed, this preferred alternative should be re-evaluated based on detailed evaluation of the range of required radon barrier thickness.
	Place more radioactive waste away from cell cover.	2	**Advantages:** Slightly less worker exposure. Slightly less radon emitted to atmosphere. (But radon barrier thickness for homogeneous option could be increased slightly to counter this.) Alternatively, may allow radon barrier to be thinner. **Disadvantages:** Construction control somewhat more involved. May have difficulty accommodating available waste schedule without extending overall schedule, which could increase worker exposure. Place waste randomly. Where convenient, route the more radioactive waste away from the cover, but only when significant extra effort is not required.	

TABLE 5.2.6-5 Observational Method: Waste Placement for Radon Control

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
1. Zonation of Radioactive Waste				
Place waste randomly with regard to radioactivity.	Volume of radioactive sludge will be great enough that it will be difficult to selectively place it away from the cell cover.	It may be possible to place the less radioactive CSS in top of cell.	Low	If less-radioactive sludge is available as described, place it near the cell cover. Otherwise, such zonation is not worth significant effort for minimal gain. Radon barrier could be thinner.

TABLE 5.2.6-6 Data Quality Objectives: Waste Placement for Radon Control

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
1. Zonation of Radioactive Waste			
Place less-radioactive sludge near the top of the cell.	Yes	Emanating fraction and diffusion coefficient for CSS grout and soil-like CSS.	Bench-scale test for emanating fraction and diffusion coefficient; do in situ test of placed waste at end of Phase I.
		Emanating fraction for VIT product.	Bench-scale test for emanating fraction; do in situ test of placed waste at end of Phase I.

Table 5.2.6-7 Compaction Criteria

Waste Type	Form During Placement	Moisture Criteria	Lift Thickness	Compaction Criteria	Comments
Raffinate sludge	Grout-like CSS.	Per treatment criteria.	1 ft – 3 ft	Minimal vibration	Vibrate with shaker-head or other attachment to excavator (not by hand).
	Soil-like CSS.	Per treatment criteria.	12 in.	90% relative compaction (RC)	Sheepsfoot compaction.
	VIT.	N/A	12 in.	90% relative compaction (RC)	Vibratory compaction.
Soils/sediments	Soil/sediment.	$WC \geq W_{opt} - 2\%^{*}$ $WC \leq W_{opt} + 3\%$	8 in. – 12 in.	Between 90% and 95% relative compaction (RC)*	Sheepsfoot compaction.
Metal	Various.	N/A	1 ft – 3 ft	N/A	Entomb with grout-like CSS**.
Masonry block	Moderately crushed.	N/A	12 in.	N/A	Entomb with CSS**.
Rock/concrete debris	3 ft maximum dimension.	N/A	1 ft – 2 ft	N/A	Entomb with CSS**.
Asbestos	Friable, bagged.	N/A	N/A	N/A	Bury in trenches; compact overburden.
	Nonfriable, primarily transite roofing or siding.	N/A	1 ft – 2 ft	N/A	Place in cell and cover.
PPE (personnel protective equipment)	Bundled, compressed.	N/A	N/A	N/A	Place in cell and cover.
Miscellaneous	Variable (office furniture, etc).	N/A	1 ft – 2 ft	Crush with track equipment.	Place in cell and cover.
Containerized chemicals (non-RCRA)	Neutralized, treated.	Per treatment criteria.	N/A	Minimal vibration.	
Soil/gravel mixtures	Soil/gravel.	$WC \geq W_{opt} - 2\%^{*}$ $WC \leq W_{opt} + 3\%$	8 in. – 12 in.	Between 90% and 95% RC.	Sheepsfoot for cohesive, rubber-tire or vibratory for granular.
Wood	Composted.	Not yielding dust.	8 in. – 12 in.	N/A	Mix with soil or gravel and compact.

Note: RC Relative compaction of maximum dry density as determined by the modified Proctor test (ASTM D1557).
* Final criteria for moisture content and degree of compaction should be determined following testing for hydrocompression as described in the text.
** For VIT, entomb metal with largest voids with clean grout from off site; fill voids in remaining metal, block, rock, and concrete with soil or vitrified frit.

TABLE 5.2.7-1 Results of Modified Value Engineering: Cover Types

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Technically Effective: Proven and demonstrated performance on other sites. Simple Construction: Easy to place and construct using standard construction procedures. Longevity: Will function throughout the 1,000 year design life. Aesthetics: Blends in well with surrounding environment.	Simple Cover.	**Advantages:** Low cost. Easy to construct. **Disadvantages** Limited biointrusion resistance. Short performance life.	Multi-Component cover.
	RCRA Cover.	**Advantages:** Good infiltration barrier. Relatively inexpensive. Aesthetically pleasing. **Disadvantages:** May not function for 1,000 yr.	
	Double Drain Cover.	**Advantages:** Technically effective: - Good erosion resistance. - Low infiltration. **Disadvantages:** Expensive. Difficult to construct.	
	Multi-component Cover.	**Advantages:** Complies with ARARS. Technically effective: low infiltration, biointrusion resistant, erosion resistant. Performance can be monitored. **Disadvantages:** Expensive. Complex construction.	
	Erosion Resister. - Vegetation Inhibitor.	**Advantages:** Complies with ARARs. Significant longevity. **Disadvantages:** Expensive.	

TABLE 5.2.7-2 Observational Method: Cover Types

Component Preferred - Multi-Component Cover

Expected Condition	Potential Deviation	Probability of Occurrence	Effect on Design	Effect on Performance
Materials readily available.	Not available.	Low	Substitute from other borrow.	None anticipated.
Normal precipitation patterns.	Too wet. Too dry.	Medium Medium	Size drains for larger capacity. Use soils with a high resistance to desiccation.	More plant life established on cover. Underlying layers more susceptible to infiltration.
No deep-rooted or woody species established on cover.	Growth on cover. Deteriorates.	Medium Low	Rely on biointrusion barrier to inhibit root advancement. Select durable rock.	Trees grow/die exposing underlying layers to erosion.

TABLE 5.2.7-3 Data Quality Objectives: Cover Types

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Abnormal precipitation patterns.	Too much rain--encourages infiltration. Too little rain--drying and cracking of cover.	How much or little precipitation can be accommodated with the cell still functioning properly? How does surficial cracking in cover affect performance?	Meteorological statistics. Test covers. Soil conservation service information.
Deep-rooted plants established on cover.	Roots penetrate into radon barrier.	How effective is biointrusion barrier in turning back roots? How effectively do plants evapotranspirate radon?	Ecological studies of local flora. Experiments.

TABLE 5.2.7-4 Results of Modified Value Engineering: Radon Barrier

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Technically Effective: Proven and demonstrated performance on other sites. Established by measurement to control radon.	Compacted Clay/Silt	**Advantages:** Conventional and proven. Simple to construct. Easy to design and analyze. Technically effective. Dual function. **Disadvantages:** Largest material volumes. Strict quality control required.	Compacted Clay/Silt
Simple Construction: Easy to place and construct using standard construction procedures.	Bentonite Amended Sand	**Advantages:** Dual function as low permeability infiltration barrier. **Disadvantages:** Susceptible to drying and cracking. Diffic ult to construct.	
Dual Function: The component may or does function also as an infiltration barrier, or biointrusion control.	Bentonite Material	**Advantages:** Simple construction. **Disadvantages:** Unproven. Thin and non-robust.	
	Waste Placement Sequence	**Advantages:** Economic. Robust. Long-term effective. **Disadvantages:** Complex construction sequencing. Infiltration barrier still required.	

TABLE 5.2.7-5 Observational Method: Radon Barrier

Component Preferred: Compacted Clay/Silt

Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design	Effect on Performance
Use locally available suitable soils (clay/silt).	Suitable soil not available. Adequate quantities not available.	Low Low	Increase radon barrier thickness. Use bentonite amendment of sandy soils.	None. None.
Minimum thickness 18 in., maximum thickness 48 in.	Design thickness required less than 18 in. Design thickness required greater than 48 in. On the basis of field measurements of as-placed waste emanation, actual required thickness between 18 in. and 48 in.	Medium Low High	Construct 18 in. thickness. Increase barrier thickness. Change cover geometry slightly. Use actual required thickness (as calculated during construction).	None.
Long-term moisture content will be that associated with -15 bar pressure.	Actual is higher. Actual is lower.	High Very low	None. Radon flux controlled/mitigated by other cover components.	Radon flux less than 20 pCi/m^2s. Radon flux may exceed 20 pCi/m^2s above radon barrier.

TABLE 5.2.7-6 Data Quality Objectives: Radon Barrier

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions To Be Answered	Data Collection Activities
Wastes have higher emanation factors than predicted. Wastes have lower emanation factors than predicted.	Increase radon barrier thickness. Decrease radon barrier thickness.	Range of waste emanation factors. Range of cover thickness.	Define waste sequence. Define waste emanation factors. Establish field construction monitoring measurement, and radon thickness determination plan.
Soils have higher/lower radon diffusion coefficients than anticipated.	Adjust radon barrier thickness.	Range of radon attenuation coefficients of suitable soils. Long-term design moisture content.	Define borrow sources and location. Collect samples. Test samples.

TABLE 5.2.7-7 Results of Modified Value Engineering: Erosion Barrier - Top Slope

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Technically effective: Proven and demonstrated performance on other sites.	Vegetated soil.	**Advantages:** Good aesthetics. Limits infiltration greatly. Low cost. Technically effective. **Disadvantages:** High maintenance requirements. Limited erosion protection.	Clump grass vegetated gravelly soil.
Simple construction: Easy to place and construct using standard construction procedures.	Clump grass vegetated gravelly soil.	**Advantages:** Erosion protection. Good aesthetics. Limits infiltration. Technically effective. **Disadvantages:** Moderate maintenance requirements.	
Longevity: Will function throughout the 1,000 yr design life.	Gravel mulch.	**Advantages:** Relatively inexpensive. Limits infiltration. Reasonable longevity. **Disadvantages:** Limited erosion protection. Poor aesthetics: reduce vegetation.	
Maintenance: Low level of upkeep involved.	Rock with soil-filled voids.	**Advantages:** Good erosion protection. Good longevity. **Disadvantages:** Expensive. Moderate maintenance requirements. Promote deep rooting species.	
Aesthetics: Blends in well with surrounding environment.	Rock.	**Advantages:** Erosion protection. Low maintenance requirements. Significant longevity. **Disadvantages:** Poor aesthetics. Poor infiltration barrier. Encourages deep rooting species.	

TABLE 5.2.7-8 Observational Method: Erosion Barrier - Top Slope

Component Preferred: Clump Grass Vegetated Gravelly Soil

Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design	Effect on Performance
Robust sand of vegetation.	Drought. Poor vegetation growth.	Medium Moderate	Select healthy grasses. Potential erosion.	Erosion, gullies, exposure of underlayers. Increased erosion potential.
Soil and gravel evenly mixed.	Uneven mixtue.	Low	High quality assurance requirements.	Erosion, gullies, exposure of underlayers.
Proper ratio of soil to gravel.	Too much gravel. Too little gravel.	Low Low	Add soil. Add gravel.	May not support desired vegetation. Erosion.
Gravel properly sized.	Gravel too large. Gravel too small.	Low Low		

TABLE 5.2.7-9 Data Quality Objectives: Erosion Barrier - Top Slope

List of Potential	Potential Deviation Affecting Design	Specific Questions to be Answered	Data Collection Activities and Design Changes
Too much or too little precipitation.	If tto much, adopt a high permeability drain. Iff too little, select hardy grasses.	How do soils respond when saturated? How quickly can/will natural growth replace growth killed by drought?	Meteorological studies. Acquire vegetation literature from Soil Conservation Service. Test cover.
Proper ratio of soil to gravel.	Too much gravel, add more soil. Too little gravel, add more gravel.	What is the proper ratio of soil to gravel?	Test cover. Soil Conservation Service.
In the medium-term (o yr to 50 yr). Failure of grass to grow.	Increase erosion potential, increased infiltration.	Monitor vegetation growth.	Remove vegetation, place rock erosion barrier.
Unacceptable erosion.	Cell integrity affected.	Monitor erosion.	Replace vegetation with rock.

TABLE 5.2.7-10 Results of Modified Value Engineering: Biointrusion Barrier

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Technically effective: Proven and demonstrated performance on other sites.	Cobble/gravel	**Advantages:** Conventional and proven. Dual function as a drain. Simple to construct. Longevity. **Disadvantages:** Possible filling of voids. Quality rock required. Questionable technical performance.	Cobble/gravel.
Simple construction: Easy to place and construct using standard construction procedures.	Thick soils	**Advantages:** Simple to construct. Significant longevity. **Disadvantages:** More expensive. May encourage root penetration. Does not provide for animal intrusion control.	
Dual function: The component may or does function as a drain layer. Longevity: Will function throughout the 1000 yr design life.	Geogrids with time - released herbicides	**Advantages:** Simple to place. Technically effective for limited time. **Disadvantages:** Will degrade over time. Layer to protect against burrowing still required.	

TABLE 5.2.7-11 Observational Method: Biointrusion Barrier

Component Preferred: Cobble/Gravel

Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design	Effect on Performance
Appropriate size cobbles available.	Suitable cobbles not available.	Low	Use larger cobbles. Use smaller cobbles.	Additional filter layer requirements. Possibility of animal penetration into radon barrier.
	Adequate quantities not available.	Low	Use thick soil layer. Use geogrid with herbicide.	
Burrowing animals in vicinity known.	Larger burrowing animals than expected.	Low	Use larger cobbles.	Burrows may reach radon barrier.
Barrier will also function as a drain in the event of drain blocking.	Voids filled with soil/silt.	Medium	Use a geotextile or good filter to trap/filter small particles.	Plants grow into radon barrier. Biointrusion barrier sorbs moisture.
Roots don't penetrate waste.	Roots penetrate waste.	Low	Increase thickness of biointrusion barrier.	Roots penetrate waste. Greater radon emanation. Greater infiltration pathways.

TABLE 5.2.7-12 Data Quality Objectives: Biointrusion Barrier

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Burrowing animals larger than expected.	Increase size of cobbles.	Size of burrowing animals. Size of cobbles available.	Determine animal sizes and burrowing habits. Determine availability of cobbles.
Voids between cobbles become filled.	Place a sand filter or geosynthetic above biointrusion barrier to catch fine particles.	Will sand/soils migrate into voids.	Test Cover.
Roots penetrate waste.	Increase thickness of biointrusion barrier.	Root growth characteristics of local flora.	Ecological studies.

TABLE 5.2.7-13 Results of Modified Value Engineering: Infiltration Barrier

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Technically effective: Proven and demonstrated performance on other sites. **Simple construction:** Easy to place and construct using standard construction procedures. **Dual function:** The component may or does function also as a radon barrier. **Longevity** Will function through the 1,000 yr design life of the disposal cell. **Redundancy** Provides back-up protection in the event of a failure.	Geomembrane	**Advantages:** Simple construction. Technically effective. **Disadvantages:** Limited life. Single function.	
	Bentonite mat	**Advantages:** Simple construction. Self repairing. Dual function. Long life. **Disadvantages:** Thin and non-robust.	Multi-component infiltration barrier
	Compacted clay/silt	**Advantages:** Conventional and proven. Simple to construct. Easy to design and analyze. Dual function. Longevity. **Disadvantages:** Largest material volumes. Strict quality control required.	
	Bentonite amended sand or clay	**Advantages:** Dual function as radon barrier. Longevity. **Disadvantages:** Susceptible to drying & cracking. Difficult to construct.	
	Multi-component infiltration barrier Geomembrane Geomat Compacted clay/silt	**Advantages:** Robust. Conventional and proven. Longest possible life. Dual function. **Disadvantages:** Relatively expensive. Complex to construct.	

TABLE 5.2.7-14 Observational Method: Infiltration Barrier

Expected Condition	Potential Deviation	Probability For Occurrence	Effect On Design	Effect On Performance
Soils Hydraulic Conductivity = 10^{-7} cm/s. Soil intact and uncracked.	10^{-8} cm/s. 10^{-6} cm/s. Soil not intact and cracking.	Low Low High during construction Low after cover placement	Adopt as specified. If economically feasible, seek other soils. Add other overburden.	Satisfactory. Increased reliance on bentonite mat. Increased hydraulic conductivity.
Bentonite Mat Hydraulic conductivity 10^{-9}cm/s. Uniform covering.	10^{-10} cm/s. 10^{-8} cm/s. Isolated patches.	Very low Low Low	Favorable Acceptable. None.	Reduced Infiltration. Satisfactory performance. Marginal increase in infiltration.
Geomembrane Transmissivity = 10^{-10}.	10^{-12} cm/s. ∞	Very low Very high	None. Ignore long-term performance assessment.	Decrease infiltration to approximately zero. Long-term infiltration controlled by other components.

TABLE 5.2.7-15 Data Quality Objectives: Infiltration Barrier

List of Potential Deviations	Potential Deviations Affecting Design	Special Questions To Be Answered	Data Collection Activities
Soils have higher/lower hydraulic activities than expected.	Adjust infiltration barrier thickness.	What soils are available?	Define Borrow. Test pads. Test samples.
Bentonite mat has higher/lower conductivities than expected.	If High, consider eliminating. If Low, consider eliminating geomembrane.	Range of hydraulic conductivity?	Refer to literature values. Refer to case history to establish viability of performance.
Geomembrane degrades over time.	Control long-term infiltration with other components.	As placed performance? Longevity?	See specifications. Define long-term.

TABLE 5.2.7-16 Results of Modified Value Engineering: Drains

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Technically effective: Proven and demonstrated performance on other sites.	Coarse sand.	**Advantages:** Conventional and proven. Simple to construct. Acts as a bedding layer. Longevity. **Disadvantages:** Significant quality assurance requirements.	Coarse sand.
Sample construction: Easy to place and construct using standard construction procedures.	Geonet.	**Advantages:** Simple to construct. **Disadvantages:** Longevity questionable.	
Longevity: Will function throughout the 1,000 yr design life.	Biointrusion barrier serving as drain.	**Advantages:** Dual function. Longevity. **Disadvantages:** Potential erosion of infiltration barrier. No bedding layer effect.	

TABLE 5.2.7-17 Observational Method: Drains

Component Preferred - Coarse Sand

Expected Condition	Potential Deviation	Probability of Occurrence	Effect on Design	Effect on Performance
Durable material.	Non-durable material.	Low	Increase layer thickness.	Decreased flow capacity.
Gradation to preclude erosion of infiltration barrier.	Too coarse.	Low	Reduce particle size. Reduce slope inclination. Increase radon barrier thickness. Alter radon barrier gradation.	Erosion of infiltration barrier soils. Cover slumping. Reduction of permeability.
Gradation to expedite seepage.	Too fine. Deteriorates.	Low Low	Increase particle size. Select durable sand.	Traps water, increases infiltration. Compromises biointrusion barrier.

TABLE 5.2.7-18 Data Quality Objectives: Drains

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Soil gradation. Fine. Coarse.	Low hydraulic conductivity. Infiltration barrier erosion.	Required gradation? Infiltration barrier soil type? Erosion potential?	Radon barrier soil properties. Sand gradations.
Soil durability.	Durability and clogging.	Available sources. Durability requirements. Durability parameters. Mineralogy. Shape. Size.	Define borrow source. Measure all physical parameters.

TABLE 5.2.7-19 Results of Modified Value Engineering: Clean-Fill Dike

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preffered Alternative
Increase constructibility. Facilitate leachate control. Increase erosion protection. Minimize maintenance. Enhance cell performance. Enhance public perception. Minimize worker exposure.	Multi-Component Cover.	**Advantages:** Less expensive. Efficient use of space. Better constructibility. **Disadvantages:** Susceptible to biointrusion. Less dynamic stability on geomembrane. More quality control required during waste placement. Susceptible to unplanned cover erosion. Higher worker exposure.	Clean-fill dike
	Clean-fill dike.	**Advantages:** Best cell performance. High slope failure safety factor. Biointrusion resistant. Minimizes worker exposure during construction. Minimizes maintenance. **Disadvantages:** Requires large volumes of clean-fill. Complicates leachate recovery.	
	Vertical face clean-fill dike.	**Advantages:** Uses less fill than standard clean-fill dike. Biointrusion resistant. Minimizes worker exposure during construction. Good cell performance. **Disadvantages:** Complex to construct. Cannot use vertical geomembrane. Complicates leachate recovery.	

TABLE 5.2.7-20 Observational Method: Clean-Fill Dike

Component Preferred: Clean-Fill Dike

Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design	Effect on Performance
Sufficient quantities of clean-fill available.	Fill not available.	Low	Define borrow. Use steeper slope.	None. Higher slope failure potential.
Cell volume < 1.5 million cu yd.	Volume > 1.5 million cu yd.	Moderate	Raise the cell. Elongate the cell.	Increased erosion and instability potential.
Performance. Stability: materials are strong.	Only low strength materials available.	Very low	Flatten slope.	Reduced factor of safety.
Infiltration: vertical or outward flow.	Bedding causes flow toward waste.	Low	Incline lifts away from wastes.	Long-term infiltration to waste.
Erosion: rock with gully resistance.	Rocks deteriorates. Gullies form. Trees disrupt rock.	Low Very low Moderate	Select durable rock. None. Maintenance control.	Reduce longevity. Increased maintenance requirements. Increased maintenance requirements.
Biointrusion: reasonable root growth.	Expensive. Deep root spread.	Low	Roots penetrate waste.	Increased maintenance requirements.

TABLE 5.2.7-21 Data Quality Objectives: Clean-Fill Dike

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Material Availability. Strength. Gradation.	Insufficient quantities. Too weak. Too coarse or too fine.	How much available and where? What are the strength of the materials? What is the permissible gradation range?	Define borrow. Conduct tests. Size of rock available.
Design Layout Set back. Slopes. Volume.	Need 300 ft. Flat slope. Steep slope. Cell volume >1.5 million cu yd, raise the cell.	Is this mandatory? What factor of safety is required? What is the increased erosion and stability potential?	Negotiate with state. Slope stability analysis. Stability and erosion studies.
Performance Stability. Infiltration. Erosion. Biointrusion.	Low strength materials available, fallen slope. Incline lifts away from waste. Rock deteriorates. Roots penetrate waste.	What factor of safety is required? What is durability of available rock? What are the root growth characteristics of local flora?	Slope stability analysis. Conduct studies. Ecological studies.

TABLE 5.2.7-22 Results of Modified Value Engineering: Erosion Protection

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preffered Alternative
Technically effective: proven and demonstrated performance on other sites. Simple construction: easy to place and construct using standard construction procedures.	Rock cover.	**Advantages:** Increased erosion protection. Minimized maintenance for erosion damage. Good biointrusion protection. Significant longevity. **Disadvantages:** Poor public perception. May not be considered aesthetic. Technically may encourage deep-rooted vegetation. Vegetation removal may increase maintenance needs.	Rock cover. Note, however, that public concerns of institutional preferences may dictate a vegetated cover.
Longevity: will function throughout the 1,000 yr design life. Maintenance: low level of upkeep involved. Aesthetics: blends in or compliments the surrounding environment.	Vegetated Cover.	**Advantages:** Very good aesthetics. Technically effective: replicates nature. Easy to construct. Will perform as natural system for a long time. **Disadvantages:** Moderate erosion protection. Periodic maintenance required.	

TABLE 5.2.7-23 Observational Method: Erosion Protection

Component Preferred: Rock Cover

Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design	Effect on Performance
Rock will be durable.	Rock deteriorates.	Low	Select durable rock.	Reduced longevity.
Resistant to gullies.	Gullies form.	Very low	None.	Increased maintenance requirements.

TABLE 5.2.7-24 Data Quality Objectives: Erosion Protection

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Rock is not durable.	Rocks deteriorates.	What is the durability of available rock?	Geological studies. Rock quality tests.
Rock is not sized properly.	Gullies form.	What size of rock is necessary for the given slope?	Erosion studies.

TABLE 5.2.7-25 Results of Modified Value Engineering: Alternative Biointrusion Approaches

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Technically Effective: Proven and demonstrated performance on other sites. Simple Construction: Easy to place and construct using standard construction procedures. Longevity: Will function throughout the 1,000 yr design life.	Rock Covered CFD	**Advantages:** Dual function as erosion barrier. **Disadvantages:** Poor public perception.	Rock cover large volume of soil.
	Soil covered CFD	**Advantages:** Good aesthetics. Simple to construct. **Disadvantages:** Requires periodical maintenance. Does not impede burrowing animals. May be damaged by animals.	
	Multicomponent covers	**Advantages:** Sod grass may be used. Visually pleasing. Technically effective. **Disadvantages:** Reduced erosion protection. Complex construction. Less mass (soil) to accommodate long-term root penetration.	

TABLE 5.2.7-26 Observational Method: Biointrusion

Component Preferred: Rock Covered CFD

Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design	Effect on Performance
Sufficient volume to accommodate root invasion.	Expansive root spread.	Low	Increased maintenance requirements.	Roots penetrate waste. Roots damage erosion protection.

TABLE 5.2.7-27 Data Quality Objectives: Biointrusion

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Biointrusion performance.	Roots penetrate waste.	What are the root growth characteristics of local flora?	Ecological studies.

TABLE 5.2.7-28 Results of Modified Value Engineering: Infiltration Control Approaches

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Technically effective: proven and demonstrated performance on other sites. Simple construction: easy to place and construct using standard construction procedures. Dual function: the component may or does function also as a biointrusion barrier. Longevity: will function throughout the 1,000 yr design life of the disposal cell.	Geomembrane on CFD.	**Advantages:** Simple Construction. **Disadvantages:** Limited life. Cannot place erosion protection rock on it.	Random soil with vertical flow.
	Compacted Clay/Silt in outer layers or zone of CFD.	**Advantages:** Conventional and proven. Simple to construct. Easy to design and analyze. **Disadvantages:** Strict quality control required.	
	Random soil in CFD enabling vertically downward flow.	**Advantages:** Simple to construct. Cost-effective. Materials readily available. Long performance life. **Disadvantages:** Layering of soil must be avoided.	

TABLE 5.2.7-29 Observational Method: Infiltration

Component Preferred: Random Soil

Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design	Effect on Performance
Soil readily available.	Soil difficult to obtain.	Low.	Define borrow.	
Soil intact and uncracked.	Soil not intact and cracking.	High during construction and low after completion.	None.	Increased infiltration.

TABLE 5.2.7-30 Data Quality Objectives: Infiltration

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Soils not easy to obtain.	Define borrow.	What soils are available?	Define borrow. Natural analogues.
Soils become saturated.	Slumping occurs.	What is the hydraulic conductivity of the soils available?	Test soils.

TABLE 5.2.7-31 Results of Modified Value Engineering: Stability

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Increase slope stability. Increase erosion protection. Enhance cell performance. Enhance public perception.	Above-grade cell with CFD (5:1 slope).	**Advantages:** Simple construction. Leachate control is simple. Good cell performance. Good public perception. **Disadvantages:** Larger footprint. Greater cell height. Increased sideslope.	Partially below-grade with 5:1 Slope.
	Below grade (or partially below grade) with CFD (5:1 slope).	**Advantages:** Reduced settlement. Reduced footprint. Reduced height/sideslope. Can construct before waste placement. Increased slope stability. Increased erosion resistance. **Disadvantages:** More complex to construct. More complex leachate control.	
	Above grade cell with no CFD (5:1 slope).	**Advantages:** Simple construction. Leachate control is simple. **Disadvantages:** Stability dependant on waste placement.	
	Below grade cell with no CFD (5:1 slope)	**Advantages:** Simple construction. **Disadvantages:** Stability dependent on waste placement. More complex leachate control.	

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TABLE 5.2.7-32 Observational Method: Stability

Component Preferred - Partially Below-Grade with 5:1 slope

Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design	Effect on Performance
Sufficient quantities of clean-fill available.	Fill not available.	Low	Use steeper slope; Define sufficient borrow.	Higher slope failure potential. None.
5:1 slope sufficient.	Unstable.	Very low	Decrease slope.	Erosion and or subsidence.
Materials are strong.	Only low-strength materials available.	Very low	Flatten slope.	Reduced factor of safety.

TABLE 5.2.7-33 Data Quality Objectives: Stability

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Material Availability. Strength.	Insufficient quantities. Too weak.	How much available and where? What are the strength of the materials?	Define borrow. Conduct tests.
Design Layout Slopes. Volume.	Flat slope. Steep slope. Cell volume > 1.5 million cu yd, raise the cell.	What factor of safety is required? What is the increased stability potential?	Slope stability analysis. Slope stability analysis.

TABLE 5.2.7-34 Results of Modified Value Engineering: Settlement

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Increase constructibility. Enhance cell performance.	Above grade.	**Advantages:** Simple construction. **Disadvantages:** Increased settlement.	Below grade.
	Partially below grade.	**Advantages:** Reduced settlement. **Disadvantages:** More complex construction.	

TABLE 5.2.7-35 Observational Method: Settlement

Component Preferred: Below Grade

Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design	Effect on Perfomrance
Uniform settlement.	Uneven settlement.	Low		Cracks form causing increased infiltration. Ponding. Flow concentration.
No cover cracking.	Cover cracks.	Low		Increased infiltration and erosion.

TABLE 5.2.7-36 Data Quality Objectives: Settlement

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Uneven settlement.	Allow for settlement in barrier design.	What are characteristics of borrow soil?	Soil testing.
Cover cracks.	Allow for settlement in barrier design.	How much settlement is expected?	Seen analogues.

TABLE 5.2.8-1 Results of Modified Value Engineering: Construction Phase Configurations, Access Locations

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Ranking]	Advantages/Disadvantages	Preferred Alternative
1. Storm Water Runoff Collection System			
Effectiveness in retaining water (21.0). Prevent Phase I (/II) runoff from leaking into clean Phase II (/Closure Phase) area. Minimize liner disturbance (13.0). Minimize disturbance of cell liner system. Mobility (0, dropped). It may be desirable to relocate, redirect, or reuse the runoff collection system. Simplicity/ease of construction (4.0). The runoff collection system should have a simple design and be easy to construct. Minimize cleanup demolition (2.0). Materials used in runoff collection will be placed in disposal cell after use.	Sandbags lifting liner. 2 Lift liner system at phase boundary. Place clean sandbags under liner to create a lined channel which prevents runoff from reaching the next phase.	**Advantages:** Very effective – liner does not let water pass beyond phase boundary. Sandbags easy to remove, might be used at boundary of next phase. Channel is very easy to construct. Easy demolition – sand bags are simply added to closure phase waste. Construction of sandbag channel does not impact cell construction. Stability – sandbags will not wash out from under liner during a storm. Capacity – bags can be piled higher to create a deeper trench, if needed. **Disadvantages:** Disturbance of liner edge. Very difficult to join Phase I and II liners. Must import sandbags. Much hand labor.	Low earth berm over bottom 1-ft to 2-ft layer of placed contaminated soil, with sandbags or berm lifting liner slightly to direct flow back toward waste until next phase of liner is ready for installation.

TABLE 5.2.8-1 Results of Modified Value Engineering: Construction Phase Configurations, Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Ranking]	Advantages/Disadvantages	Preferred Alternative
Impacts to cell construction (7.0). The storm water collection system must not interfere with progression of cell construction. Capacity (16.0). How much runoff the system can hold before water must be pumped to another location. Allow room for vehicles (7.0). The runoff detention system should leave room for vehicles to drive into the cell area to place waste. Robustness, durability (16.0). How the system withstands the effects of storms, construction activity.	Low contaminated soil berm over bottom 1-ft to 2-ft layer of contaminated soil, with sandbags or berm lifting liner slightly to direct flow back toward waste until next phase of liner is ready for installation. Line flow channel (with HDPE?) to prevent erosion. See Figure 3.	1	**Advantages:** Very effective – liner prevents erosion and prevents water from escaping channel. Relatively easy to construct to any height. Easy clean-up : demolition – soil is spread and compacted. Variable capacity – can pile more dirt to create a deeper channel. **Disadvantages:** Soil berm may erode away if not carefully compacted or protected. Must import sandbags. Much hand labor.	
	Culvert at phase boundary. Construct culvert below edge of liner.	4	**Advantages:** Very effective – runoff is collected in culvert, while liner prevents contamination of soil. Stability – culvert will hold its shape in storms and under traffic loading. Vehicles can drive over culvert. **Disadvantages:** Disturbs liner system. Construction is not as simple as methods which just lift liner. Must fill in culvert at end of construction phase.	

TABLE 5.2.8-1 Results of Modified Value Engineering: Construction Phase Configurations, Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Ranking]	Advantages/Disadvantages	Preferred Alternative
	Concrete trench. Construct concrete trench at phase boundary, below edge of liner. 5	**Advantages:** Very effective – no runoff falls on new phase clean area. Excellent stability. Might be able to leave trench in place (not demolish). **Disadvantages:** Construction of concrete trench may impede cell construction. More work involved in clean-up demolition, if trench is to be removed at end of phase. Cannot increase trench capacity easily.	
	Earth dike lifting liner. Construct a soil dike at phase boundary. Lift liner over dike to create a lined channel which prevents runoff from reaching the next phase. 3	**Advantages:** Very effective - liner prevents water from escaping channel. Channel is easy to construct. Easy to increase capacity by building up dike. Since dike is above liner, can use contaminated soil from site. **Disadvantages:** Disturbs edge of liner system. Complications when construction begins. Must use clean soil under liner. Dike might erode if not carefully constructed and protected.	

TABLE 5.2.8-1 Results of Modified Value Engineering: Construction Phase Configurations, Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Ranking]	Advantages/Disadvantages	Preferred Alternative
2. Location of Storm Water Runoff Detention During Phase I, Prior to Runoff Being Pumped Elsewhere for Retention			
Gravity flow from cell to basin (9.0). Storm water runoff should flow readily to the selected detention basin. Low impact to cell construction (4.0). Detention basin should located so as not to interfere with cell construction. Ease of pumping to raffinate Pit 2 (3.0). Detention basin should be located near Raffinate Pit 2 so that excess water can easily be pumped there. (See MVE on pumping and storing excess runoff.)	Detention basin 4 (APID). 1 Direct storm water runoff from disposal cell to APID. Excavate a pond to retain runoff at this location. May need small pond on cell to direct water into pipes, which will carry water to APID. May need pumps to boost flow.	**Advantages:** Close to Phase I boundary. Runoff likely flow by gravity to the APID. Capacity now large enough or can be enlarged to store design storm. Not located on disposal cell area – low impact on cell construction operations. Contaminated runoff from Phase I area is directed away from clean Phase II area. **Disadvantages:** May cause difficulty for site roads on West side of disposal cell. Contamination of clean basin.	Direct stormwater runoff from disposal cell to APID. Excavate a pond to retain runoff at this location.
Proximity to Phase I boundary (5.0). Detention basin should be located close to the Phase I boundary. Capacity (11.0). The detention basin should have a large capacity for cell runoff (in addition to any water it already holds). Minimize area occupied (0.0, dropped). Due to limited space on site, the detention basin should occupy a small area. Prevent contamination of Phase II (16.0). The area under the Phase II liner must not be contaminated by runoff from Phase I waste.	Phase I area. 4 Create small runoff detention basin in Phase I area.	**Advantages:** Easy collection of Phase I runoff. Contaminated runoff is retained in contaminated area. Contaminated water is prevented from reaching Phase II clean area. **Disadvantages:** May interfere with waste placement/cell construction. Would have small capacity – must provide large pumping capacity to keep up with storm runoff. Pumps would occupy valuable space and require. decontamination after pumping dirty water.	

TABLE 5.2.8-1 Results of Modified Value Engineering: Construction Phase Configurations, Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Ranking]	Advantages/Disadvantages	Preferred Alternative
	Raffinate Pit 4. Direct storm water runoff to Raffinate Pit 4. 2	**Advantages:** Large capacity: If water could be directed here, it would not be necessary to pump water to another location later. Runoff is directed away from clean Phase II area. **Disadvantages:** Water will not flow by gravity from disposal cell to Raffinate Pit 4. It would have to cross a site road and a raffinate pit dike. It may be desirable to drain parts of Raffinate Pit 4 for exploration.	
	Phase II area. Create small runoff detention basin in Phase II area. 5	**Advantages:** Proximity to Phase I boundary. Ease of directing runoff to basin. May have larger capacity than a detention basin located in Phase I area. **Disadvantages:** Must devise a means of preventing contaminated water from reaching clean soil under Phase II (Pond liner?). May interfere with Phase II construction. Small capacity relative to runoff detention basin outside cell area - may need many pumps.	
	Raffinate Pit 2. Direct runoff to Raffinate Pit 2. 3	**Advantages:** Capacity of Raf. Pit 2. Proximity to Phase I boundary Alternative D-D. **Disadvantages:** Does not work well for Phase I configuration preferred alternative. Runoff would not flow by gravity to Raffinate Pit 2. If capacity of Raffinate Pit 2 is exceeded, must pump water to Raffinate Pit 4.	

TABLE 5.2.8-1 Results of Modified Value Engineering: Construction Phase Configurations, Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives (Final Ranking)	Advantages/Disadvantages	Preferred Alternative
	MSA Pond. Direct Phase I cell runoff to MSA Pond. 7	**Advantages:** Proximity to Phase I boundary. Most likely beyond Phase II boundary (could be used again during Phase II). Water is directed to a contaminated pond, not a clean area. **Disadvantages:** Clean Phase II area lies between Phase I boundary and MSA Pond – potential contamination of Phase II clean soil. Low capacity – may not hold more than MSA runoff. Distance from Ref. Pit 2, where extra runoff is to be pumped.	
	Ash Pond. Direct Phase I runoff to Ash Pond. 6	**Advantage:** Runoff is directed to a contaminated pond. **Disadvantages:** Low capacity – may not hold cell runoff. Difficulty in directing water to Ash Pond.	

TABLE 5.2.8-1 Results of Modified Value Engineering: Construction Phase Configurations, Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives (Final Ranking)	Advantages/Disadvantages	Preferred Alternative
3. Storm Water Runoff Detention During Phase II			
Gravity flow from cell to basin (9.0). Storm water runoff should flow readily to the selected detention basin. Low impact to cell construction (4.0). Detention basin should located so as not to interfere with cell construction. Ease of pumping to Raffinate Pit 2 (3.0). Detention basin should be located near Raffinate Pit 2 so that excess water can easily be pumped there. (See MVE on pumping and storing excess runoff. Proximity to Phase II boundary (5.0). Detention basin should be located close to the Phase II boundary.	APID. 1 Direct storm water runoff to Detention Basin 4. Excavate a pond to retain the water.	**Advantages:** Proximity to Phase II boundary. Easy flow from cell to basin. Can excavate pond or raise dike for more capacity. Low impact on cell construction. Contaminated runoff directed away from clean soil in closure phase area. Preferred alternative for runoff collection during Phase I. **Disadvantages:** May cause difficulty for site roads on west side of cell. Encroaches upon Phase II clean fill dike.	Direct storm water runoff to Detention Basin 4. Excavate a pond to retain the water.
Capacity (11.0). The detention basin should have a large capacity for cell runoff (in addition to any water it already holds).	Phase II Area. 4 Construct runoff detention basin in closure phase area.	**Advantages:** Easy collection of runoff. Runoff is retained in contaminated area. **Disadvantages:** May interfere with waste placement/cell construction. Small capacity – may require a lot of pumping.	

TABLE 5.2.8-1 Results of Modified Value Engineering: Construction Phase Configurations, Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Ranking]	Advantages/Disadvantages	Preferred Alternative
Minimize area occupied (0.0, dropped). Due to limited space on site, the detention basin should occupy a small area.	Closure phase area. 6 Construct runoff detention basin in Closure Phase area.	**Advantages:** Proximity to Phase II boundary. If closure phase is very small, a basin here might be used through most of Phase II construction. **Disadvantages:** May interfere with closure phase construction. Special precautions to prevent contamination of clean soil in closure phase area.	
Prevent contamination of closure phase (16.0). The area under the closure phase liner must not be contaminated by runoff from Phase I and Phase II waste.	MSA Pond. 5 Direct cell runoff to MSA Pond.	**Advantages:** Proximity to Phase II boundary. Runoff is retained in a contaminated pond. If closure phase is small, MSA Pond might be used through most of Phase II construction. **Disadvantages:** May interfere with closure phase construction. Clean area of closure phase lies between Phase II boundary and MSA Pond. Insufficient capacity - barely enough for MSA runoff.	
	Raffinate Pit 2. 3 Direct cell runoff to Raffinate Pit 2.	**Advantages:** Large capacity. Runoff is directed away from clean closure phase area. **Disadvantages:** Difficulty in directing water flow from cell to Raffinate Pit 2. Must pump to Raffinate Pit 4 if Raffinate Pit 2 capacity is exceeded.	

TABLE 5.2.8-1 Results of Modified Value Engineering: Construction Phase Configurations, Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Ranking]	Advantages/Disadvantages	Preferred Alternative
	Raffinate Pit 4. Direct cell runoff to Raffinate Pit 4.	2	**Advantages:** Small chance of exceeding capacity. Runoff is directed away from clean closure phase area. **Disadvantages:** Difficulty in directing runoff to Raffinate Pit 4. It may be desirable to drain Raffinate Pit 4 for exploration.	
	Ash Pond. Direct cell runoff to Ash Pond.	7	**Advantage:** Runoff is directed to a contaminated pond. **Disadvantages:** Difficulty in directing runoff to Ash Pond.	
4. Pumping and Storage of Excess Cell Runoff (Excess runoff is that which cannot be handled within the site water treatement plant facilities.)				
Capacity of storage location (7.0).	Pump to Raffinate Pit 2 first pump excess water from detention basin to Raffinate Pit 2, then to Raffinate Pit 4, if necessary.	1	**Advantages:** Raffinate Pit 2 water can be treated by both WTP trains, so water treatment process is facilitated. Pumping water to Raffinate Pit 2 first allows exploration of Ref. Pit 4. Raffinate Pit 2 already contains contaminated water – cell runoff is not pumped to a clean area or new equipment. **Disadvantages:** Distance of Raffinate Pit 2 from disposal cell will probably require long pipes and high pumping from the runoff detention basin.	Pump to Raffinate Pit 2 first pump excess water from detention basin to Raffinate Pit 2, then to Raffinate Pit 4, if necessary.

TABLE 5.2.8-1 Results of Modified Value Engineering: Construction Phase Configurations, Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Ranking]	Advantages/Disadvantages	Preferred Alternative
The location to which excess cell runoff is pumped should have a large capacity.	Pump to Raffinate Pit 4 first pump excess water from cell runoff detention basin to Raffinate Pit 4. 2	**Advantages:** Facilitates water treatment process - water can be treated by both WTP trains. Large capacity of Raffinate Pit 4. Runoff is not pumped to a clean area or equipment. Proximity to disposal cell. **Disadvantages:** Exploration of Raffinate Pit 4 may require removal of water from this pit.	

TABLE 5.2.8-1 Results of Modified Value Engineering: Construction Phase Configurations, Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives (Final Ranking)	Advantages/Disadvantages	Preferred Alternative
Facilitate water treatment process (10.0). Pump excess cell runoff to a location near the WTP. Also, minimize the amount of water which must go through the denitrification process. Use existing water storage space (3.0). Excess cell runoff should not be pumped to an area which does not already contain contaminated water. Facilitate raffinate pit exploration (4.0). Raffinate Pit 4 should be excavated first, because it has a shallow depth of sludge. The soil beneath Raffinate Pit 4 could then be explored to estimate the amount of waste from all pits. Proximity to disposal cell (3.0). Excess cell runoff should be pumped to a location near the disposal cell boundary in order to minimize the length of pipe and effort required to pump the water. Minimize equipment contamination (3.0). Minimize use of equipment (e.g., pumps, pipes, tanks) which must either be decontaminated or added to disposal cell.	Pump to storage tanks. 3 Pump excess water from cell runoff detention basin to storage tanks at phase boundary.	**Advantages:** Proximity to disposal cell. Water can be transported directly to WTP. Can get more tanks for more capacity when needed. Mobility - tanks can be relocated to the boundary of each new phase. **Disadvantages:** Contamination of tanks. Potential capacity problems if not enough tanks are used.	

TABLE 5.2.8-1 Results of Modified Value Engineering: Construction Phase Configurations, Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Ranking]	Advantages/Disadvantages	Preferred Alternative
5. Cell Closure (Placing initial temporary cover/radon barrier over waste)				
Protect CFDs from contaminated runoff (13.0). Prevent runoff from cell from flowing onto the CFDs. Ease of cover placement (3.0). Facilitate operation of covering the waste. Clean equipment access to cover (6.0). Allow clean delivery vehicles to drive onto cover without contacting waste. Minimize contaminated runoff (0, dropped). Minimize area of waste exposed to precipitation. Coordinate with waste placement (5.0). Facilitate placing of upper lifts of waste while placing cover. Minimize contamination to new cover (13). Minimize likelihood of the temporary cover/radon barrier becoming contaminated after placement.	Begin cover with edge. As waste placement approaches the top of the CFDs, it will be sloped away from the CFDs. As this surface rises, it will meet the design top-of-waste grade, and no further waste will be placed at that location. Place temporary cover as waste reaches top elevation, working from the perimeter inwards.	2	**Advantages:** Adequately protects CFDs from becoming contaminated once cover placement begins. Very easy access for clean equipment carrying cover material. **Disadvantages:** Would require special effort to keep contaminated runoff from contacting the lower edge of the new cover.	Leave channel around perimeter. When waste reaches top of CFDs, leave channel in waste (40 ft - 50 ft wide?) around perimeter. Place remaining waste to full height and cover. Finally, place waste to design height in channel, beginning at up-gradient location and moving down.
	Leave channel around perimeter. When waste reaches top of CFDs, leave channel in waste (40-50 ft wide?) around perimeter. Place remaining waste to full height and cover. Finally, place waste to design height in channel, beginning at up-gradient location and moving down.	1	**Advantages:** Adequately protects CFDs from becoming contaminated once cover placement begins. Can place nearly all waste without special coordination with cover operation (but see Disadvantages). **Disadvantages:** Final waste placement will be in tight quarters to fill channel. Clean vehicle access to cover will be longer route to go around channel (or place a culvert?).	

TABLE 5.2.8-2 Observational Method: Construction Phase Access Road Surface

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
1. Storm Water Runoff Collection System				
Build berm/dike with liner, and place clean sandbags under liner at phase boundary to prevent runoff from reaching the next phase.	Channel collects all cell runoff and directs it to detention basin.	Capacity is exceeded.	Low	Make weld between liners ASAP to minimize impact, i.e. to protect LDCRS.
2. Storm Water Runoff Detention During Phase I				
Direct storm water runoff to Detention Basin 4. Excavate a pond to retain runoff at this location.	All cell storm water will be stored temporarily in Detention Basin 4.	A large storm causes runoff to exceed detention basin capacity.	Medium	Operate pumps continuously to remove cell runoff to Raffinate Pit 2.
3. Storm Water Runoff Detention During Phase II				
Direct storm water runoff to Detention Basin 4.	Cell runoff is directed to Detention Basin 4.	Runoff does not flow readily from Phase II boundary to APID.	Low	Construct small detention basin in Phase II area.
4. Pumping and Storage of Excess Cell Runoff				
Pump excess cell runoff from cell runoff detention basin to Raffinate Pit 2.	Raffinate Pit 2 has adequate capacity to hold excess water from cell runoff detention basin.	Raffinate Pit 2 cannot hold all of the excess water from the cell runoff detention basin.	Low to Medium	Pump excess water from cell runoff detention basin to Raffinate Pit 4.
	Design storm hits after RP-2 is empty.	Design storm hits before RP-2 is empty.	Low	Pump to RP-4.
	Pumps will operate during and following storm.	Pumps or power could fail.	Medium	Provide redundant pumps/power, or extra storage in APID.

TABLE 5.2.8-2 Observational Method: Construction Phase Access Road Surface (Continued)

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
5. Cell Closure				
Leave channel around perimeter; when waste reaches top of CFDs, leave channel in waste (40 ft - 50 ft wide?) around perimeter. Place remaining waste to full height and cover. Finally, place waste to design height in channel, beginning at up-gradient location and moving down.	Will be able to place temporary cover over all of a single phase before winter shuts down operation.	A whole phase may not be ready for cover when winter arrives (this is expected after first portion of Phase I, and is not the subject of this deviation).	Medium	Either: Raise a portion of the waste to final elevation and cover, or leave waste exposed through the winter

TABLE 5.2.8-3 Data Quality Objectives: Access Road Surface

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
1. Storm Water Runoff Collection System			
Capacity is exceeded.	Yes	Likelihood and consequences of occurrence. Potential prevention and mitigation measures.	Cell layout, phase layout, orientation and slope of edge of phase, location of detention.
Design storm hits before Raffinate Pit 2 is empty.	Yes	Likelihood of occurrence.	Dates of start of cell work.
2. Storm Water Runoff Detention During Phase I			
A large storm causes runoff to exceed detention capacity of APID.	Yes	What is the capacity of APID?	Cost of pumping water away from cell. Potential for increasing capacity of APID.
Pump or power failure.	Yes	Design storm; storage capacity; pump capacity.	Design storm criteria (back-to-back storms?), APID and cell layout/ topography.
3. Storm Water Runoff Detention During Phase II			
Runoff does not flow readily from Phase II boundary to APID.	Yes	Flow potential from Phase II to APID.	Elevation of edge of Phase II. Length of flow. Hydrograph and required flow from cell.

TABLE 5.2.8-3 Data Quality Objectives: Access Road Surface (Continued)

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
4. Pumping and Storage of Excess Cell Runoff			
Raffinate Pit 2 cannot hold all of the excess water from the cell runoff detention basin.	Yes	Will Raffinate Pit 2 hold all of the water in excess of the cell runoff detention basin capacity?	Expected extra capacity of Raffinate Pit 2 during design storm. Expected extra capacity of Raffinate Pit 4 during design storm. Expected capacity of cell runoff detention basin. Expected volume of cell runoff during design storm (for each phase).
5. Cell Closure			
A whole phase may not be ready for cover when winter arrives.	Yes	Start date of waste placement.	Forecast beginning of cell operations (design and build) and waste placement.
		Duration and end date of waste placement.	Forecast rates of waste processing and placement.

TABLE 5.2.9-1 Results of Modified Value Engineering: Construction Phase Configurations Access Locations

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Ranking]		Advantages/Disadvantages	Preferred Alternative
1. Phase I Configuration				
Follow 1% Slope (0, dropped).	South to north, near Raffinate Pit 3 Construct Phase I from south to north, with boundary at line A–A.	1	**Advantages:** Follows 1% slope of disposal cell. Large capacity (≈ 650,000 cu yd). Runoff flows readily to an existing detention basin (Detention Basin 4). **Disadvantages:** Site road has limited space between clean-fill dike and Raffinate Pit 3 dike. Clean-fill dike must have a steeper slope to avoid Raffinate Pit 3 dike. Material excavated from chemical plant area will require double handling.	Construct Phase I from south to north, with Phase I boundary at Line A–A.
Cell construction should progress in the direction of the disposal cell slope to simplify construction and facilitate runoff collection.	South to north, below Raffinate Pit 3. Construct Phase I from south to north, with Phase I boundary at line B–B.	5	**Advantages:** Clean-fill dike would not reach Raffinate Pit 3 dike. Easy access from north-south running site road, until Phase II is begun. Runoff readily flows to southwest for easy collection. Construction follows 1% slope of cell surface. **Disadvantages:** Too small capacity (≈ 375,000 cu yd) – fatal flaw. Site road will have limited space between clean-fill dike and Raffinate Pit 3 dike. Material excavated from chemical plant area will require double handling.	

TABLE 5.2.9-1 Results of Modified Value Engineering: Construction Phase Configurations Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Ranking]	Advantages/Disadvantages	Preferred Alternative
Avoid Raffinate Pit 3 dike (5.5). The Phase I clean-fill dike should not become contaminated by the Raffinate Pit 3 dike. Easy access from site roads (6.0). Site roads should have clear, direct access to Phase I area for as long as possible. Facilitate runoff drainage (11.0). Phase I configuration should facilitate drainage and collection of storm water runoff and later pumping of stormwater to raffinate pits. Storm water will most likely be retained to the southwest of the cell. Space for CMSA (2.0, dropped). The Phase I configuration should allow adequate space for the CMSA. Large working area (13.0). Phase I should have a large area to facilitate waste placement. Large capacity (13.0). Phase I should have a capacity greater than 500,000 yd^3 to allow for contingency in quantity of waste to be placed in Phase I. Minimize runoff (12.0). Minimize storm water runoff from disposal cell.	Southeast to northwest construct Phase I from southeast to northwest, with Phase I boundary at line C–C. [2-tied]	**Advantages:** Clean-fill dike will not approach contaminated Raffinate Pit 3 dike. North-south running site road has easy access to Phase I area, until Phase II is begun. Large capacity (≈ 560,000 cu yd). **Disadvantages:** Construction does not follow 1% of cell surface, i.e., drainage along edge of phase goes to north, away from detention ponds. Material excavated from chemical plant area will require double handling.	

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TABLE 5.2.9-1 Results of Modified Value Engineering: Construction Phase Configurations Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Ranking]		Advantages/Disadvantages	Preferred Alternative
	East to west Construct Phase I from east to west, with Phase I boundary at line D–D. Use top of bays to form edge of Phase I to help control runoff.	2-tied	**Advantages:** Clean-fill dike does not reach Raffinate Pit 3 dike. Large working area. Easy access from both north and south (whole west side open). Large capacity (≅ 580,000 cu yd). Some contaminated soils at south end do not need to be excavated during Phase I thus avoiding possible double handling. **Disadvantages:** Does not follow slope of disposal cell. Difficulty in directing runoff to southwest, where it will most likely be retained (east has more clean areas). A large portion of east side clean-fill dike must be constructed during Phase I, so material cannot be stored there.	
	North to south Construct Phase I from north to south, with boundary at line E–E.	5	**Advantages:** Easy access from contaminated areas. Large working area. Boundary is perpendicular to direction of 1% slope. Clean-fill dike would not approach Raffinate Pit 3 dike. Double handling of excavation of contaminated soil in Phase I area can be avoided. **Disadvantages:** Phase I occupies space needed for MSA (fatal flaw). Difficulty in drainage: cell slopes to north. If overflow reaches LCRS, plugging could occur.	

TABLE 5.2.9-1 Results of Modified Value Engineering: Construction Phase Configurations Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Ranking]	Advantages/Disadvantages	Preferred Alternative
	South to north, intermediate boundary. Construct Phase I from south to north, with Phase I boundary at line B–A.	4	**Advantages:** Clean-fill dike will not approach contaminated Raffinate Pit 3 dike until Phase II is begun. North-South running site road has easy access to Phase I area. Construction progresses in direction close to that of cell's 1% slope. Adequate capacity (≈510,000 cu yd). **Disadvantages:** Only moderate working area.	
2. Phase II Configuration				
Continue in direction of Phase I selected alternative. The Phase I preferred (1st) alternative, and 2nd ranked alternatives will be considered.	Continue Phase I preferred alternative (Line A–A) to line A–A. Follow 1% slope as in Phase I.	not ranked	**Advantages:** ≈400,000 cu yd capacity in Phase II. Runoff would flow readily along Phase II boundary to the Southwest of cell. Large working area. **Disadvantages:** Smaller working area as Phase II progresses north.	Continue Phase I alternative. Boundary of Phase II is line A–A or B–B.
Capacity. Phase II should have a minimum capacity of about 400,000 yd^3 of waste.	Continue Phase I 2nd ranked alternative (Line C–C) to Line A–A. Construct Phase II from southeast to northwest.	not ranked	**Advantages:** ≈400,000 cu yd capacity in Phase II. Runoff would flow readily to southwest. Large working area. **Disadvantages:** Irregular-shaped working area.	
	Continue Phase I 2nd ranked alternative (Line D–D) to Line B–B. Construct Phase II from east to west.	not ranked	**Advantages:** >500,000 cu yd capacity in Phase II. Runoff would flow readily to northwest. Could use bays to contain and direct runoff. Large working area. **Disadvantages:** Long narrow working area may cause some difficulties (undetermined).	

TABLE 5.2.9-1 Results of Modified Value Engineering: Construction Phase Configurations Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Ranking]	Advantages/Disadvantages	Preferred Alternative
3. Access Route to Phase I After Start of Phase II			
Potential Phase II contamination (9.0). Minimize potential for contamination of clean soil under Phase II area. Length of travel to access (4.0). Minimize length of travel for vehicles transporting waste into the cell. Effect on cell drainage system (6.0). Minimize interference with Phase I runoff collection and detention system. Potential contamination of CFD (7.0). Minimize potential for contamination of clean-fill dike around Phase I area. Impacts to cell construction (5.0). Access to Phase I area should allow timely progress of waste placement and cell construction. Flexibility (1.0, dropped). Potential difficulties with access as waste reaches greater heights.	Two ramps over CFD. 1 Construct two ramps over the Phase I clean-fill dike from the north-south site road (east of cell) to the Phase I waste placement area. The two ramps will meet at the top of the clean-fill dike, where a ramp slopes down to the waste placement area.	**Advantages:** Vehicles do not disturb or contaminate Phase II area. Access is provided for vehicles transporting waste from the north and from the south. Ramps over CFD would not interfere with the cell runoff collection system. Vehicles can drive waste into cell. **Disadvantages:** Vehicles transporting waste from north must travel farther to unload waste. Precautions must be taken to prevent contamination of clean-fill dike.	For Alternative A-A, use two ramps over CFD. Construct two ramps over the Phase I clean-fill dike from the north-south site road (east of cell) to the Phase I waste placement area. The two ramps will meet at the top of the clean-fill dike, where a ramp slopes down to the waste placement area. However, direct access for Alternative D-D is highest overall score in MVE.

TABLE 5.2.9-1 Results of Modified Value Engineering: Construction Phase Configurations Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Ranking]	Advantages/Disadvantages	Preferred Alternative
	One ramp over CFD. Construct a ramp over the Phase I clean-fill dike from the north-south site road to the Phase I area. 2	**Advantages:** Vehicles do not disturb or contaminate Phase II construction area. Does not interfere with the cell runoff collection system. Vehicles can drive into cell to place waste. **Disadvantages:** Vehicles transporting waste from opposite direction of ramp must travel to start of ramp and make sharp turns. Potential congestion at bottom of ramp from turning vehicles. Not much more difficult to construct two ramps, which improves travel from north and south. Precautions necessary to prevent contamination of clean-fill dike.	
	Ramp over CFD from south and direct ramp into cell from north. Construct a ramp over the Phase I clean-fill dike for northbound traffic. Construct a ramp directly to top of waste for southbound traffic. 3	**Advantages:** Vehicles travelling from both north and south have short, direct access to cell. Direct ramp to waste could be constructed with contaminated soil from site. Less potential of cross-contamination of CFD than two-ramp alternative. **Disadvantages:** Precautions necessary to prevent contamination of clean-fill dike. Ramp from north should cross clean Phase II area -- potential contamination of Phase II foundation. Direct ramp from north would cross runoff collection system at edge of Phase I.	

TABLE 5.2.9-1 Results of Modified Value Engineering: Construction Phase Configurations Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	(Final Ranking)	Advantages/Disadvantages	Preferred Alternative
	Direct ramp from southbound site road into Phase I area construct a ramp in the Phase II area directly from the site road to the top of Phase I waste.	3	**Advantages:** Vehicles travelling from north have short, direct access to cell. Eliminates hazard of contaminating clean-fill dike. Ramp could be constructed of contaminated soil from the site. **Disadvantages:** Vehicles transporting waste from south must travel farther to place waste. Potential contamination of Phase II foundation. Interferes with Phase I runoff collection system.	
	Prohibit driving into Phase I area after Phase II construction begins. Use another method (e.g., crane) to place waste.	drop	**Advantage:** Minimizes potential for contamination of CFD and/or Phase II area. **Disadvantages:** OK if used in addition to driving waste into cell, but otherwise would impede cell contamination. More handling of waste required.	
	Direct access, from west, with alternate layout D-D. Use one or two access locations from west, across Phase II area. Easiest access, but may need to move access roads one time to build Phase II LCRS.	1	**Advantages:** Shortest access. No haul over CFD. **Disadvantages:** Need to control runoff from access road across Phase II.	

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TABLE 5.2.9-1 Results of Modified Value Engineering: Construction Phase Configurations Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Ranking]	Advantages/Disadvantages	Preferred Alternative
4. Access Route to Phase II After Start of Closure Phase Construction			
Potential closure phase contamination (9.0).	Two ramps over CFD. 1 Construct two ramps over the Phase II clean-fill dike from the north-south site road (east of cell) to the Phase II waste placement area. The two ramps will meet at the top of the clean-fill dike, and will connect to the site road at a point south of the Raffinate Pit 3 dike.	**Advantages:** Vehicles do not disturb or contaminated closure phase area. Access is provided for vehicles transporting waste from the north and from the south. Ramps over CFD would not interfere with the cell runoff collection system. Vehicles can drive waste into the cell. Not much more difficult to construct two ramps, which improves travel from north and south **Disadvantages:** Vehicles transporting waste from north must travel farther to unload waste. Precautions must be taken to minimize contamination of clean-fill dike.	Two ramps over CFD. Construct two ramps over the Phase II clean-fill dike from the north-south site road (east of cell) to the Phase II waste placement area. The two ramps will meet at the top of the clean-fill dike, and will connect to the site road at a point south of the Raffinate Pit 3 dike. However, depending on locations of waste remaining during Phase II, only one ramp may be necessary.

TABLE 5.2.9-1 Results of Modified Value Engineering: Construction Phase Configurations Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Ranking]	Advantages/Disadvantages	Preferred Alternative
Minimize potential for contamination of clean soil under closure phase area. Length of travel to access (3.0). Minimize length of travel for vehicles transporting waste into the cell. Effect on cell drainage system (4.0). Minimize interference with cell runoff collection and detention system. Potential contamination of CFD (6.0). Minimize potential for contamination of clean-fill dike around Phase II area. Impacts to cell construction (10.0). Access to Phase II area should allow timely progress of waste placement and cell construction. Flexibility (1.0, dropped). Potential difficulties with access as waste reaches greater heights. Disturbance of Phase I cover (10.0). Minimize potential for contamination of Phase I cover material.	One ramp over CFD. Construct a ramp over the Phase I clean-fill dike from the north-douth site road to the Phase II area.	2	**Advantages:** Vehicles do not disturb or contaminate Phase II construction area. Does not interfere with the cell runoff collection system. Vehicles can drive into cell to place waste. **Disadvantages:** Potential congestion at bottom of ramp from turning vehicles. Precautions necessary to minimize contamination of clean-fill dike.	

TABLE 5.2.9-1 Results of Modified Value Engineering: Construction Phase Configurations Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives (Final Ranking)	Advantages/Disadvantages	Preferred Alternative
	Ramp over CFD from south and direct ramp into cell from north. Construct a ramp over the Phase II clean-fill dike for northbound traffic. Construct a ramp directly from site road to waste for southbound traffic. drop	**Advantages:** Vehicles travelling from both north and south have a short, direct path to the cell. Ramp to waste can be constructed with contaminated soil on site. **Disadvantages:** Precautions will be necessary to prevent contamination of clean-fill dike. Ramp from north to cell would cross clean closure phase area. Direct ramp to waste would cross runoff collection system at Phase II boundary.	
	Ramp directly from north-south site road to waste. Construct a ramp in the closure phase area from the site road directly to the top of the waste. drop	**Advantages:** Ramp directly to waste could be constructed with contaminated soil on site. Eliminates hazard of contaminating clean-fill dike. **Disadvantages:** Potential for contamination of closure phase area. Ramp would interfere with runoff collection system. Longer route from south.	
	Ramp over Phase I cover drop	**Advantage:** Vehicles drive over "sealed" area to drop waste in Phase II. **Disadvantage:** Could damage Phase I cover.	

TABLE 5.2.9-1 Results of Modified Value Engineering: Construction Phase Configurations Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives (Final Ranking)		Advantages/Disadvantages	Preferred Alternative
	Prohibit driving into Phase II area. Use special equipment to place waste without allowing vehicles to drive into Phase II area after start of Closure Phase.	drop	**Advantage:** Minimizes potential for contamination of clean-fill dike and closure phase area. **Disadvantages:** More handling of waste required. OK if used in addition to driving waste into cell, but otherwise would impede cell construction	
5. Clean Access to Cell for Cover Placement				
Minimize equipment contamination (4.0). Prevent the contamination of vehicles transporting clean materials to the cell, so that these vehicles do not need to be decontaminated before returning to the clean site road.	Ramp over east CFD. Construct ramp over clean-fill dike from clean site road on east side of cell. Probably build CFD steeper than 5:1 so ramp will be part of final CFD.	1	**Advantages:** Direct access from clean site road which leads to CMSA and off-site borrow. Ramp over CFD is clean, so vehicles can remain uncontaminated. Progression of cover placement can go southeast to northwest, like waste placement. **Disadvantages:** Must take precautions so that vehicles transporting cover materials do not contact waste and become contaminated. Must prevent dirty vehicles from driving down clean ramp to clean site road (see MVE on demarcation of dirty/clean site roads – Section 5.1.5).	Ramp over east CFD. Construct ramp over clean-fill dike from clean site road on east side of cell. It may be possible to use same ramp for Phase I and II (and closure?)

TABLE 5.2.9-1 Results of Modified Value Engineering: Construction Phase Configurations Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives (Final Ranking)	Advantages/Disadvantages	Preferred Alternative
Efficient cover placement (4.0). Enable quick, efficient transportation of clean materials to cell. Prevent contamination of site road (9.0). Prevent the contamination of the clean site road on the east side of the cell. This road leads to the CMSA and offsite borrow, and is the most likely route for vehicles delivering cover materials to the cell. Short travel distance to cell (0.0, dropped). Minimize the distance traveled by vehicles transporting clean material for the cell cover.	Drop material with special equipment. Use special equipment (cranes, etc.) to drop cover material onto cell, without letting clean vehicles drive onto cell. drop	**Advantages:** Clean vehicles do not risk being contaminated by driving onto cell. Dirty vehicles on cell have no access to clean site road. **Disadvantages:** Impedes cover construction: clean material must be driven to special equipment, then unloaded and placed on cell. Limited space for equipment on east side of cell.	
Prevent contamination of CFD (5.0). Minimize the potential for contamination of the clean-fill dike, especially on the east side of the cell, near the clean site road.	Use dirty ramps. Vehicles transporting clean cover materials travel around to east side of cell to use dirty ramps (see MVEs on cell access – Section 5.1.2.9). drop	**Advantages:** Dirty vehicles on cell have no access to clean site road. Do not have to construct more ramps over clean-fill dike. **Disadvantages:** Long distance for clean vehicles to travel to reach ramps on west side of cell. Vehicles must be decontaminated after contacting waste and/or dirty ramps.	

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TABLE 5.2.9-1 Results of Modified Value Engineering: Construction Phase Configurations Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	(Final Ranking)	Advantages/Disadvantages	Preferred Alternative
6. Construction of Contaminated Roads Over Clean-Fill Dike				
Minimize contamination of clean soil (5.0). Prevent contaminated material and runoff from ramps from penetrating the clean-fill dike or ramp soil.	Surface course over geotextile build soil ramp, cover with geotextile and liner then cover with surface course (soil or gravel). Slope into CFD. Build lined ditch.	1	**Advantages:** Contaminated surface course is segregated from subgrade. Easy clean-up demolition. Liner prevents infiltration potential contamination into material below subgrade. **Disadvantages:** Geotextile added to waste. Geotextile placement is extra construction step.	Surface course over geotextile. Build soil ramp, cover with geotextile and liner, then cover with base course (soil or gravel). A gravel surface friction course will probably be needed for tire traction. Slope into CFD. Build lined ditch.
Ease of construction (1.0). The ramps over the clean-fill dike should be easy and fast to construct. Ease of clean-up and reconstruction of clean-fill dike (3.0). Minimize necessary clean-up of dike after use of ramps. Ramp performance (5.0). How well the ramp withstands the action of heavy construction vehicles. Not impede construction (7.0). Provide all-weather access, minimal maintenance.	Unsurfaced road on soil ramp.	2	**Advantages:** Ease of construction. **Disadvantages:** Greater contamination of CFD must be cleaned. Increased maintenance.	

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TABLE 5.2.9-1 Results of Modified Value Engineering: Construction Phase Configurations Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Ranking]	Advantages/Disadvantages	Preferred Alternative
7. Surfacing of Cell Roads				
Impacts to cell construction (10.0). Construction of cell roads should not impede cell construction.	Soil or soil-like CSS.	1	**Advantages:** Ease of construction. Can use contaminated soil within cell. Easy to demolish and add surface material to cell as waste. Adequate performance for short-term. **Disadvantages:** Potentially slippery on inclines – may need gravel surface course on ramps. Rutting. May require extra grading/regrading for long use. Construction vehicles might get stuck in clayey soils when it rains.	All cell roads will have dirt surfaces. Dirt roads are preferred slightly, with gravel roads scoring nearly as well, especially if contaminated gravels can be used. Geotextile may be used if needed. Soil-like CSS may also be used when it is available. Gravel or soil-like CSS may be particularly attractive during rainy periods of construction or for roads to be used for a longer period of time, although a gravel surface friction course will probably be needed.
	Gravel.	2	**Advantages:** Ease of construction. Good performance. Easy to demolish and add to cell. May be able to use gravel waste and not increase waste volume. Can be abandoned in place. **Disadvantages:** Must import gravel to construct. May be unnecessary for short design life	

TABLE 5.2.9-1 Results of Modified Value Engineering: Construction Phase Configurations Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Ranking]	Advantages/Disadvantages	Preferred Alternative
Ease of construction (3.0). Cell roads should be fast and easy to construct. Minimize use of special equipment (4.0). To minimize necessary decontamination of equipment used in disposal cell, minimize use of special equipment for cell road construction. Surface performance (10.0). Performance and durability of cell roads under heavy equipment loading. Public perception (0.0, dropped). Public opinion of the safety and appearance of cell roads. Minimize clean-up demolition (3.0). Minimize amount of additional material which must be placed in disposal cell after use of cell roads.	Chip seal.	3	**Advantages:** Very good appearance for good public perception. Good Performance. **Disadvantages:** Construction vehicles may break up chip seal. Must use imported materials. Special equipment required to construct. Too much effort for short design life.	
	Asphalt concrete.	4	**Advantages:** Excellent performance. Very good appearance/public perception. **Disadvantages:** Extra work and special equipment needed to construct. Too much effort for short design life. Work involved in clean-up demolition.	

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TABLE 5.2.9-1 Results of Modified Value Engineering: Construction Phase Configurations Access Locations (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Ranking]	Advantages/Disadvantages	Preferred Alternative
	Portland cement concrete. 6	**Advantages:** Excellent performance. Very good appearance/public perception. **Disadvantages:** Likely to crack. Extra work and materials involved in construction. Work involved in clean-up demolition. Waiting for cure impedes cell construction. Too much work for short design life.	

TABLE 5.2.9-2 Observational Method: Construction Phase Access Road Surface

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
1. Phase I Configuration				
Construct Phase I from south to north, following 1% slope of cell, with Phase I boundary at line B–B shown in Figure 1 of the MVE.	Phase I boundary leaves adequate room between the clean-fill dike and the Raffinate Pit 3 dike.	More space is needed on the west side of the cell during Phase I due to contamination from Raffinate Pit 3.	Low to Medium	Construct Phase I from southeast to northwest or east to west, with Phase I boundary at line C–C, D–D, or B–A.
	Phase I preferred alternative has adequate capacity (≈519,000 cu yd).	Larger Phase I capacity is desired.	Low	Increase size of Phase I.
2. Phase II Configuration				
Continue cell construction with Phase II in the direction of the Phase I preferred alternative.	Phase I preferred alternative is constructed.	Phase I alternative C–C is constructed.	Medium	Continue with Phase II to Line A–A.
		Phase I alternative D–D is constructed.	Medium	Continue with Phase II to Line B–B.
3. Access to Phase I After Start of Phase II				
Construct two ramps over the Phase I clean-fill dike from the north-south site road (east of cell) to the Phase I waste placement area.	Vehicles transporting waste to Phase I will drive on north-south site road and up ramps over CFD to place waste.	No vehicles allowed to drive over CFD.	Low	Use Alternative C–C or D–D.
4. Access to Phase II After Start of Closure Phase				
Construct two ramps over the Phase II clean-fill dike from the north-south site road (east of cell) to the Phase II waste placement area.	Vehicles transporting waste to Phase II will drive on the north-south dirty site road and up ramps over the CFD to place waste.	No vehicles allowed to drive over CFD.	Low	Construct closure phase from east to west, to leave room for a dirty ramp directly up to the waste at the Phase I boundary. Must close with multicomponent cover, not CFD.

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TABLE 5.2.9-2 Observational Method: Construction Phase Access Road Surface (Continued)

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
5. Clean Access to Cell for Cover Placement				
Construct a ramp over the CFD from the clean site road on east side of cell.	Vehicles will be able to place clean cover ahead of themselves and remain uncontaminated.	Trucks will become contaminated by contacting waste.	Medium	Provide close control of operation. Provide monitoring and contingency dry decontamination operation on cell if needed.
6. Dirty Road Construction Over Clean-Fill Dike				
Build ramp at 10:1 slope from site road to top of CFD. Place geotextile and liner over ramp and cover with gravel.	Road will adequately support traffic.	Road ruts excessively or gets slippery.	Medium	Increase compaction and/or thickness of surface course(gravel); increase maintenance.
	Two ramps.	Less than two ramps.	Medium	None
7. Cell Roads Surfacing				
All cell roads will have dirt surfaces.	Dirt roads are adequate for transportation within the cell area. Contaminated soils on-site are used to construct cell roads.	Roads rut excessively or get slippery with wet weather.	Medium	Could add gravel surface course and/or geotextile to cell roads during construction.

TABLE 5.2.9-3 Data Quality Objectives: Construction Phase Access Road Surface

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
1. Phase I Configuration			
More space needed adjacent to RP-3.	Yes	Extent of contamination to be cleaned up.	Explore plume and contamination levels and areal extent.
Larger Phase I needed.	Yes	What will be start date of waste placement?	How many months will be available before desired Phase closure at winter shutdown?
Cell configuration not known.	Yes	Additional consideration of layout needed before final design proceeds far.	Cell layout, Sections 5.8.2 and 5.8.3.
Allowable foundation excavation and final grade below current design.	Yes		
2. Phase II Configuration			
Alternative C-C is selected.	Yes	Additional study is needed to compare orientation of phases.	Cell layout, Sections 5.8.2 and 5.8.3.
Alternative D-D is selected.	Yes		
3. Access to Phase I After Start of Phase II			
No vehicles allowed over CFD	Yes	None.	
4. Access to Phase II After Start of Closure Phase			
No vehicles allowed over CFD	Yes	None.	
5. Clean Access to Cell for Cover Placement			
Trucks become contaminated by contacting waste.	No		
6. Dirty Ramps Over Clean Fill Dike			
Road ruts excessively or gets slippery.	Yes	Traffic loading, road stability.	Equipment to be used, number of loads, soil CBRs, etc.
Less than two ramps	No		

TABLE 5.2.9-3 Data Quality Objectives: Construction Phase Access Road Surface (Continued)

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
7. Cell Roads Surfacing			
Roads rut excessively or get slippery.	Yes.	Traffic loading, road stability.	Equipment to be used, number of loads, soil CBRs, etc.

TABLE 5.3.1-1 USGS Report Mineralogic and Chemical Analyses of Sludge Samples from Raffinate Pit 3 (SEM, Scanning Electron Microscope; mg/kg, milligrams per kilogram; <, less than; --, no data)

Mineralogic Analysis					
X-ray diffraction (semiquantitative)	Predominantly apatite with minor quartz, hornblende, amorphous ion oxides, and trace flakes of graphite		Gypsum 40-75%; sellaite (MgF_2, 10-40%); apatite 5-15%; MgF_2 (10-40%); quartz 5-10%; goethite and other iron oxides (about 5%)		
SEM	Scattered grains of carnotite		Carnotite, undetermined U-rich phase		
Element	Unit	0-4.6 ft	0-9 ft composite samples (1990)		
		Composite (1989)	Sample 1	Sample 2	Sample 3
Calcium	weight percent	20	16	16	17
Phosphorus	weight percent	10	3.2	3.8	4.0
Iron	weight percent	6.9	5.2	5.5	5.8
Magnesium	weight percent	3.5	4.3	2.5	2.6
Aluminum	weight percent	1.5	2.7	2.5	2.6
Sodium	weight percent	0.90	1.8	1.7	1.8
Potassium	weight percent	0.11	0.19	0.19	0.19
Titanium	weight percent	0.06	0.14	0.14	0.15
Arsenic	mg/kg	360	1,490	1,260	1,330
Barium	mg/kg	230	130	207	221
Cadmium	mg/kg	2.5	3.8	3.2	3.5
Cesium	mg/kg	4.3	--	--	--
Chromium	mg/kg	104	181	217	219
Cobalt	mg/kg	11	37	61	63
Copper	mg/kg	850	1,430	1,310	1,380
Lead	mg/kg	205	889	1,770	1,840
Lithium	mg/kg	177	133	96.1	100
Manganese	mg/kg	620	4,060	3,190	3,350
Molybdenum	mg/kg	368	1,410	1,250	1,310
Nickel	mg/kg	120	768	175	186
Scandium	mg/kg	17	72	78	81
Silver	mg/kg	1	--	--	--
Strontium	mg/kg	127	279	302	318
Thorium	mg/kg	1,290	4,740	7,760	8,010
Tin	mg/kg	166	37	5	<1
Uranium	mg/kg	1,700	3,680	3,300	3,470
Vanadium	mg/kg	1,300	7,740	6,970	7,330
Yttrium	mg/kg	22	350	551	569
Zinc	mg/kg	127	410	392	409
Zirconium	mg/kg	530	--	--	--
Neodymium	mg/kg	--	94	122	126
Beryllium	mg/kg	--	8.7	8.1	8.3
Cerium	mg/kg	--	174	217	222
Europium	mg/kg	--	6.2	7.4	7.6
Gallium	mg/kg	--	53	82	86
Holmium	mg/kg	--	18	29	30.9
Lanthanum	mg/kg	--	77	99	103
Ytterbium	mg/kg	--	54	76	79

TABLE 5.3.2-1 Material Balance: Consolidated

Materials	Stream ID	OP-II-1 Monolithic Product		OP-III-6 Soil-like Product		QUARRY SOILS* Monolithic Product	
		Bench-Scale (1b)	Full Scale (5 yd batch) (Ton)	Bench-Scale (1b)	Full Scale (5 yd batch) (Ton)	Bench-Scale (1b)	Full Scale (5 yd batch) (Ton)
Sludge (Pit #3) 64% Moisture	A	1	4.54	1	3.05	-	-
Surface Soils 18.4% Moisture	H	0	-	1	3.04	-	-
Quarry Soils 7.6% Moisture	F	-	-	-	-	1	3.38
Water Added	B	0	0	0	0	0.5	1.68
F.A.	E	0.24	1.086	0.12	0.366	0.54	1.824
P.C.	D	0.16	0.724	0.08	0.244	0.36	1.216
Total Binder		0.4	1.81	0.2	0.61	0.9**	3.04
Grout	G	1.4	6.31	-	-	2.4	8.1
Soil-like	I	-	-	2.2	6.7	-	-

* Not Optimized

** When ratio is calculated on the basis of weight of binder + weight of (QS + water), the result is 0.6 (vs. 0.9) - per ORNL formula

Reference: Waste Technologies Group, Inc. (WTG) - CSS Testing of Raffinate Pit Sludges and Nitroaromatic Soils, Preliminary Design Report, May 1992.

TABLE 5.3.3-1 Leaching Test (TCLP & EP-TOX) Results for WSS Vitrified Waste Forms (in $\mu g/l$)

Glass Tested	Additives %	Cr	As	Se	Ag	Cd	Ba	Hg	Pb
WS-1 (VSL/CUA, TCLP)	30	<0.	25	<1000	6	18	518	<0.	<0.
WS-2 (")	20	<0.	13	<1000	2	12	910	14	<0.
WS-3 (")	10	133'	42	<1000	<0.	5	95	<0.	14
WS-4 (")	10	<0.	209	<1000	<0.	26	882	<0.	37
WS-5 (")	10	<0.	84	303	<0.	3	752	<0.	41
WS-6 (")	10	<0.	59	604	<0.	<0.	320	<0.	22
WS-7 (")	None	<0.	109	0.	<0.	4	329	<0.	<0.
WS-8 (")	10	<0.	93	22	<0.	<0.	280	<0.	20
WS-9 (")	10	<0.	23	42	<0.	<0.	116	<0.	4
WS-10 (")	10	<0.	867	0.	4	13	690	18	<0.
WS-11 (")	20	172	94	0.	36	6	260	2	<0.
WS-12 (")	20	61	126	820	5	<0.	789	<0.	<0.
TCLP Limits	-	5,000	5,000	1,000	5,000	1,000	1.0E05	200	5,000
Similated WSM-5 (PNL, EP-TOX)	25	<1,000	<1,000	<10	<100	<10	40	<30	<1,000
EP-TOX Limits	-	5,000	5,000	1,000	5,000	1,00	1.0E05	200	5,000

TABLE 5.3.3-2 Waste Balance for Vitrification Treatment at 125, 140, and 200 TPD (Solids) Throughputs

Process Stream[a]	Operation at 125 TPD (Solids)			Operation at 140 TPD (Solids)			Operation at 200 TPD (Solids)		
	Gross Material (TPD)	Equiv. Dry Solids (TPD)	Water (TPD)	Gross Material (TPD)	Equiv. Dry Solids (TPD)	Water (TPD)	Gross Material (TPD)	Equiv. Dry Solids (TPD)	Water (TPD)
1[b]	78.1	62.5	15.6	87.5	70.0	17.5	125.0	100.0	25.0
2[b]	78.1	62.5	15.6	87.5	70.0	87.5	125.0	100.0	25.0
3	15.0	0.0	15.0	16.8	0.0	16.8	24.0	0.0	24.0
4	15.0	0.0	15.0	16.8	0.0	16.8	24.0	0.0	24.0
5[c]	63.1	62.5	0.6	70.7	70.0	0.7	101.0	100.0	1.0
6[c]	63.1	62.5	0.6	70.7	70.0	0.7	101.0	100.0	1.0
7	126.3	125.0	1.3	141.4	140.0	1.4	202.0	200.0	2.0
8[d]	1.8	0.6	1.2	2.1	0.7	1.4	3.0	1.0	2.0
9	0.6	0.6	0.0	0.7	0.7	0.0	1.0	1.0	0.0
10[e]									
11 & 12	125.0	125.0	0.0	140.0	140.0	0.0	200.0	200.0	0.0

(a) Process streams are defined on Figure 5.3.3.4.1.
(b) Feed at 80% solids
(c) Material @ 99% solids
(d) Assumes 0.5% solids carryover
(e) See Section 5.3.3.4.9, Tables 5.3.3.4.1 and 5.3.3.4.2, for detail

TABLE 5.3.3-3 Mass Flows for Off-Gas Treatment System[a]

Process Stream[b]	Operation at 125 TPD Gross Material (TPD)	Operation at 180 TPD Gross Material (TPD)
1	1.98	2.86
2	1.03	1.54
3	Variable	Variable
4	1.25	1.79
5	1.32	2.53
6	0.54	0.77
7	1.16	1.66
8	0.01	0.01
9[c]	1.44 (TPY)	1.44 (TPY)
10[d]		

(a) Selected mass flows are only listed to show major inputs such as reagents, and outputs such as residual sludge flows and are not balanced because species such as NO_x and SO_2 are not considered.
(b) Process streams are defined on Figure 5.3.3.4.7.
(c) Filters are recycled only once per year.
(d) See Table 5.3.3.4.3 for details.

TABLE 5.3.3-4 Estimated Fate of Constituents

Contaminant	Destroyed, Removed or in Frit (%)	Scrubber Residuals for Disposal (%)	Released to the Atmosphere (lbs/hr) 120 tons/day Feed Rate	Released to the Atmosphere (lbs/hr) 180 tons/day Feed Rate
Metals				
Lead	93.46	6.54	1.6E-07	2.23E-07
Arsenic	78.50	21.50	7.9E-07	1.13E-06
Cadmium	76.05	23.95	4.4E-08	6.39E-08
Selenium	0.14	99.86	3.0E-07	4.34E-07
Mercury	0.01	99.99	6.2E-03	0.00902
Copper	99.70	0.30	1.4E-09	1.94E-09
Nickel	99.70	0.30	1.5E-09	2.2E-09
Chromium	99.70	0.30	1.8E-10	2.65E-10
Vanadium	99.70	0.30	1.4E-08	1.98E-08
Zinc	97.61	2.39	1.1E-08	1.51E-08
Acid Gases				
Sulfate	60.01	35.99	2.39	3.45
Chloride	2.88	96.17	0.05	0.07
Fluoride	99.69	0.31	1.6E-05	2.36E-05
Nitrites	60.00	20.00	0.08	0.114
Nitrates	60.00	20.00	8.07	11.53
Organic-NO_2	60.00	20.00	0.06	0.06
Thermal NO_x	60.00	20.00	4.89	6.75
Nitro-Aromatics				
2,4,6-TNT	<0.10	<0.10	0	0
2,4-DNT	<0.10	<0.10	0	0
2,6-DNT	<0.10	<0.10	0	0
Radionuclides				
Total U	99.7	0.3	1.76E-09	2.51E-09
Th-230	99.70	0.30	9.85E-13	1.38E-12
Th-232	99.70	0.30	5.07E-09	7.83E-09
Particulates "Carry-through" + recycled calcium from spray dryer	99.95	0.05	5.2E-07	7.43E-07

TABLE 5.3.4-1 Debris Characterization Major Groupings and Their Components

GROUP 1 — FRIABLE AND MANMADE MINERAL FIBER

Friable asbestos-containing material (ACM)
- floor, wall, ceiling, window, equipment mastics
- dry wall compounds (sampled no ACM detected)
- floor tile
- floor leveling compounds
- floor underlayments
- lab equipment ACM rope - HVAC insulation
- pipe joints
- bricks (ACM)
- pipe insulation
- tank insulation

Manmade mineral fiber materials:
- fiberglass insulation
- rockwool insulation
- equipment filters
- ceiling tiles
- wall acoustical tiles
- ceiling acoustical tiles

GROUP 2 — VEHICLES, ENGINES, AND SIMILAR TYPES OF MISCELLANEOUS METALS

Equipment with sheet metal surfaces include:
- cars
- trucks
- air handling
- exhaust fans
- hoods } lab equipment & process equipment
- vents }
- rail yard engine (referred to on-site as locomotive)
- boilers
- dry transformers
- calciner oven
- motor control center
- MCC panels
- power panels
- dust collection equipment
- reactor furnaces
- reduction furnaces
- nitric acid absorber column Building 108
- reconcentrator column Building 108

Solid equipment includes:
- engine blocks
- lathes
- coring equipment
- front-end loaders
- process equipment
- electric motors
- blending vessels and tanks
- pumps, electric
- piping pumps/valves
- scales (remove lead weights from scales and store in Building 434)

GROUP 3 — STAINLESS STEEL

Group 3 material includes:
- stainless steel
- pipes, tanks, vessels, and equipment
- structural members and sheeting

GROUP 4 — PIPES

Group 4 material includes:
- Pipe less than 12 in. in outside diameter with fittings, valves, and appurtenances intact
- Pipe greater than 12 in. in outside diameter with fittings, valves, and appurtenances removed
- Product process pipe

TABLE 5.3.4-1 Debris Characterization Major Groupings and Their Components (Continued)

GROUP 5 — MISCELLANEOUS METALS	
Reinforcing steel includes: - steel bars - welded wire fabric - steel strand - electrical conduit	Miscellaneous metals include: - pipe fittings - electrical connectors - castings - light fixtures - valves - nuts and bolts - small pieces of equipment - short curved piping - sag rods - fenceposts/fencing

GROUP 6 — NON-METAL DEBRIS
Non-metal debris includes: - plastic - glass - paper products - floor scrapings - general trash - collected "housecleaning debris" - diatomaceous earth HEPA vacuum dust will be collected as a result of demolition"housecleaning."

GROUP 7 — SHEET METAL
Bulky sheet metal includes: - metal desks - file cabinets - metal laboratory benches - supply closets - lockers - ductwork - control boxes - man-doors - fireproof cabinets/safes

GROUP 8 — PCB CONTAMINATED MATERIALS
PCB Contaminated Material - equipment - concrete placed in roll offs at MSA - pipe - any contaminated material

GROUP 9 — SELECT MATERIAL
Select Material includes: - oils - thorium compounds - yellow cake - greensalt residues

TABLE 5.3.4-1 Debris Characterization Major Groupings and Their Components (Continued)

GROUP 10 — NONFRIABLE ASBESTOS-CONTAINING MATERIAL	
Nonfriable asbestos-containing materials (siding and sheets) includes: - siding sheets - shielding sheeting - partitions	
GROUP 11 — ASBESTOS-CONTAINING MATERIAL	
Built-up roofing includes: - lightweight concrete roof decking	
GROUP 12 — STRUCTURAL STEEL	
Structural steel includes: - columns - beams - crane rails - girts - purlins - railroad rail	
GROUP 13 — PLATE STEEL	
Plate steel includes: - metal decking - towers, tanks - tanks - vessels - steel siding - roofing	Metal siding, roofing, and decking includes: - metal decking - expanded metal decking - corrugated steel siding - corrugated steel roofing - aluminum siding - aluminum roofing - aluminum decking
GROUP 14 — RUBBLE	
Concrete slabs include: - slabs on grade - deck slabs - elevated slabs Concrete piers include: - drilled foundation piers with belled bottoms	Concrete footings include: - isolated footings - continuous footings Masonry blocks include: - brick - cinderblock - porcelain
(PCB-contaminated concrete will be stored at MSA in roll-off boxes until final disposal.)	
GROUP 15 — RAILROAD RAILS	

TABLE 5.3.4-1 Debris Characterization Major Groupings and Their Components (Continued)

GROUP 16 — LARGE WOOD PIECES
Wood materials include: - telephone poles - railroad ties - office furniture - doors - partitions - structural timbers
GROUP 17 — WOOD (SPECIAL) - Cooling tower
GROUP 18 — MISCELLANEOUS NON-METALS
Miscellaneous non-metals material include: - graphite pipe - graphite sheeting - diatomaceous earth
GROUP 19 — SPECIAL METALS
Special metals include: - aluminum · siding · deck plate · structural shapes - lead · shielding · scale weights · drain pipe seals - copper · bus bars · wire conductors · wire in conduit · wire in motors

TABLE 5.3.4-2 Results of Modified Value Engineering: Optimize Material Sizing For Cell Disposal

Evaluation Criteria	Alternative	Advantage	Disadvantage	Preferred Alternative
Worker health and safety. Facilitate placement in cell. Cell volume reduction. Minimize labor intensity. Relative unit cost. Facilitate cell performance.	Dismantle material.	Minimizes worker health and safety risks. Minimizes process and handling. Minimizes void space. Reduces overall cell volume by accommodating CSS grout or VIT sand. No impact on final decision.	Additional sizing required if recycling is chosen. Additional attention during placement. Requires CSS grout or VIT sand to fill voids.	Dismantle material.
	Dismantle material for recycling.	Achieves maximum cell volume reduction. Minimizes void space/maximum cell performance.	Higher unit cost. Higher health and safety risks. Additional handling.	
	Melt material.	Moderate cell reduction. Moderate cell performance. Higher relative unit cost.	High health and safety risks. Additional handling.	
	Compact material.	Moderate cell performance. Higher relative unit cost.	High health and safety risks. Additional handling.	
	Shred material.	Lower relative unit cost than cryofracture material.	High health and safety risk. Additional handling. Lower cell performance.	
	Cryofracture material.		High health and safety risk. Additional handling. Lower cell performance.	

TABLE 5.3.4-3 Results of Modified Value Engineering: Size Reduction

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
GROUP 1 — FRIABLE ACM AND MANMADE MINERAL FIBER - No additional alternatives where considered.			
GROUP 2 — VEHICLES, ENGINES, AND SIMILAR TYPES OF MISCELLANEOUS METALS - No additional alternatives were considered.			
GROUP 3 — STAINLESS STEEL - No additional alternatives were considered.			
GROUP 4 — PIPES			
Any pipe less than 12 in. diameter. Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment. Consider cost — Additional processing costs must provide sufficient benefits.	Cut into relatively straight lengths of about 8 ft. NOTE: Only exception to 8 ft sizing of steel pipes is product process pipes 12 in. outside diameter or less; these will be sized to 20 ft lengths and placed in roll-off containers.	**Advantage:** Facilitates handling.	Cut into relatively straight lengths. Four types: - pipe general (8 ft lengths) stored at shreddable area, MSA - product process pipe (size 20 ft lengths) place in roll-off containers and store at MSA in product process pipe area - all pipes from Buildings 108, 403 and 404, sized as above but place in roll-off containers and transport to TSA. - stainless steel to stainless steel area at MSA

TABLE 5.3.4-3 Results of Modified Value Engineering: Size Reduction (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
All 12 in. outside diameter and greater cut to 8 ft lengths and split in half. Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment. Consider cost — Additional processing costs must provide sufficient benefits.	Cut pipe into lengths of about 8 ft or less; place at the MSA until final disposal. Cut pipe into lengths of about 8 ft or less; place at the MSA until final disposal.	**Advantage:** Lower costs. **Disadvantage:** Promotes large voids during long-term disposal. **Advantage:** Flattening reduces voids. **Disadvantage:** Higher cost.	Cut pipe into appropriate lengths; place at the MSA until final disposal. Three types: - pipe general (size 8 ft lengths, then split in half to MSA nonshreddable area) - product process pipe (size 8 ft lengths, split in half, decontamination interiors and to MSA nonshreddable area) - All pipes from Building 108 sized as above but place in roll-off containers, transport to TSA
Reinforced concrete pipe greater than 12 in. in diameter. Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment. Consider cost — Additional processing costs must provide sufficient benefits.	Rubblize concrete; separate steel and concrete; place steel at the MSA and concrete at the Ash Pond. Separate at joints; stack at the MSA; fill with treated sludge during final disposal.	**Advantage:** None. **Disadvantage:** Considerable steel wire and reinforcing steel will be exposed, requiring handling and storage. Additional material transportation costs from Ash Pond. **Advantage:** None. **Disadvantage:** Pipe will require support during filling.	Separate at joints; stack at the MSA; fill with treated sludge during final disposal.

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TABLE 5.3.4-3 Results of Modified Value Engineering: Size Reduction (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Cast iron greater than 12 in. in diameter. Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment. Consider cost — Additional processing costs must provide sufficient benefits.	Separate at joints; crush pipe to expose center; place at the MSA until final disposal.	Not applicable.	Separate at joints; crush pipe to expose center; place at the MSA until final disposal.
GROUP 5 — MISCELLANEOUS METALS			
Reinforcing steel conduit Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment. Consider cost — Additional processing costs must provide sufficient benefits.	Compress into relatively dense bales. Form a mass at the MSA. Shear into lengths of about 4 ft or less; pile at the MSA.	**Advantage:** Facilitates handling. Safer. **Disadvantage:** Requires the use of a baler for increased cost. **Advantage:** None. **Disadvantage:** Will require cutting before final disposal. **Advantage:** Facilitates handling. **Disadvantage:** None.	Shear into lengths of about 4 ft or less; pile at the MSA.

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TABLE 5.3.4-3 Results of Modified Value Engineering: Size Reduction (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
GROUP 6 — NON-METAL DEBRIS			
Non-metal debris. Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment. Consider cost — Additional processing costs must provide sufficient benefits.	Load debris into roll-off boxes; place loaded boxes in MSA until final disposal. Crush debris before loading into roll-off boxes; place loaded boxes in MSA until final disposal.	**Advantage:** Does not require special processing to reduce size. **Advantage:** Allows more debris to be placed in roll-off boxes. **Disadvantage:** Extra cost does not appear to provide a substantial benefit.	Load debris into roll-off boxes; place loaded boxes in MSA until final disposal.
GROUP 7 — SHEET METAL			
Bulky sheet metal. Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment. Consider cost — Additional processing costs must provide sufficient benefits.	Crush bulky objects to approximately two-dimensional shapes; pile at the MSA. Shred to reduce bulk; pile at the MSA. Compress into approximate 2-ft to 3-ft bales; stack at the MSA.	**Advantage:** Low cost. **Disadvantage:** None **Advantage:** None **Disadvantage:** Higher cost does not appear to provide a substantial benefit. **Advantage:** Obtain dense bales. Facilitates subsequent handling. Bales can be stacked, requiring less temporary storage area. Potentially a beneficial waste form for long-term disposal. **Disadvantage:** Requires the use of a baler for substantially increased cost.	Crush bulky objects to approximately two-dimensional shapes; pile at the MSA.

TABLE 5.3.4-3 Results of Modified Value Engineering: Size Reduction (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
GROUP 9 — PCB-CONTAMINATED MATERIAL			
Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment. Consider cost — Additional processing costs must provide sufficient benefits.	Take slabs at any size that can be handled to the Ash Pond until final disposal.	**Advantage:** None. **Disadvantage:** May require cranes, large trucks, and other heavy equipment at each stage of handling.	Break slabs into pieces with a nominal 3-ft maximum dimension; pile at the Ash Pond until final disposal.
	Break slabs into pieces with a nominal 3-ft maximum dimension; pile at the Ash Pond until final disposal.	**Advantage:** Can be handled with ordinary front-end loaders and dump trucks. **Disadvantage:** Will require additional handling and cutting of rebar.	
GROUP 9 — SELECT MATERIALS - No additional alternatives were evaluated.			

TABLE 5.3.4-3 Results of Modified Value Engineering: Size Reduction (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
GROUP 10 — NONFRIABLE ASBESTOS-CONTAINING MATERIAL			
Nonfriable ACM (Siding & Sheets)	Band in 4-ft high bundles at building locations; stack in MSA until final disposal.	**Advantage:** Facilitates final placement. Minimizes exposure. Requires less area in MSA. **Disadvantage:** Possible higher cost due to up-front labor.	Band in 4-ft high bundles at building locations; stack in MSA until final disposal.
Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment.	Randomly pile at MSA until final disposal.	**Advantage:** Requires less up-front labor. **Disadvantage:** MSA piles will likely be low and require larger area due to potential for sliding sheets.	
Consider cost — Additional processing costs must provide sufficient benefits.	Break up and pile at MSA until final disposal.	**Advantage:** Handle with front-end loaders. **Disadvantage:** Promotes exposure.	

TABLE 5.3.4-3 Results of Modified Value Engineering: Size Reduction (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
GROUP 11 — ASBESTOS-CONTAINING MATERIAL			
Nonfriable ACM (Roofing) Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment. Consider cost — Additional processing costs must provide sufficient benefits.	Take slabs at any size that can be handled to the Ash Pond until final disposal.	**Advantage:** None. **Disadvantage:** May require cranes, large trucks, and other heavy equipment at each stage of handling.	Break slabs into pieces with a nominal 3-ft maximum dimension; pile at the Ash Pond until final disposal.
	Break slabs into pieces with a nominal 3-ft maximum dimension; pile at the Ash Pond until final disposal.	**Advantage:** Can be handled with ordinary front-end loaders and dump trucks. **Disadvantage:** Will require additional handling and cutting of rebar.	
GROUP 12 — STRUCTURAL STEEL			
Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment. Consider cost — Additional processing costs must provide sufficient benefits.	Take steel pieces 30 ft or 5000 lbs, whichever is greater, or shape that can be handled to the MSA until final disposal.	**Advantage:** None. **Disadvantage:** Will require more temporary storage space. May require additional handling/moving equipment.	Cut steel into reasonably straight lengths of 30 ft or 5000 lbs; remove projections to within 1 ft of steel shapes; place in MSA until final disposal.
	Cut steel into reasonably straight lengths of about 16 ft or less; remove projections to within 1 ft of steel shapes; place in MSA until final disposal.	**Advantage:** Facilitates handling at all stages. **Disadvantage:** None.	
	Decontaminate.	**Advantage:** Does not require disposal in cell. **Disadvantage:** Extreme cost.	

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TABLE 5.3.4-3 Results of Modified Value Engineering: Size Reduction (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
GROUP 13 — PLATE STEEL			
Plate steel Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment. Consider cost — Additional processing costs must provide sufficient benefits.	Cut into approximately 4 ft x 8 ft sheets or smaller; place at the MSA until final disposal. Decontaminate.	**Advantage:** Facilitates handling. **Disadvantage:** None. **Advantage:** Does not require disposal in cell. **Disadvantage:** Extreme cost.	Cut into approximately 4 ft x 8 ft sheets or smaller; place at the MSA until final disposal.
Metal Siding, Roofing, and Decking Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment. Consider cost — Additional processing costs must provide sufficient benefits.	Cut into approximately 4 ft x 8 ft sheets or smaller; band in 4-ft high bundles; place at the MSA until final disposal. Compress into approximately 2- to 3-ft bales; stack at the MSA until final disposal.	**Advantage:** Low cost. **Disadvantage:** None. **Advantage:** Obtain dense bales. **Disadvantage:** Requires the use of a baler for increased cost.	Cut into approximately 4 ft x 8 ft sheets or smaller; band in 4-ft high bundles; place at the MSA until final disposal.

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TABLE 5.3.4-3 Results of Modified Value Engineering: Size Reduction (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
GROUP 14 — RUBBLE			
Concrete slabs Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment. Consider cost — Additional processing costs must provide sufficient benefits.	Take slabs at any size that can be handled to the Ash Pond until final disposal. Break slabs into pieces with a nominal 3-ft maximum dimension; pile at the Ash Pond until final disposal.	**Advantage:** None. **Disadvantage:** May require cranes, large trucks, and other heavy equipment at each stage of handling. **Advantage:** Can be handled with ordinary front-end loaders and dump trucks. **Disadvantage:** Will require additional handling and cutting of rebar.	Break slabs into pieces with a nominal 3-ft maximum dimension; pile at the Ash Pond until final disposal.
Concrete footings Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment. Consider cost — Additional processing costs must provide sufficient benefits.	Break into any size that can be handled; place in the Ash Pond until final disposal. Break into pieces with a nominal 3-ft maximum dimension; remove stem walls; pile in the Ash Pond until final disposal.	**Advantage:** None. **Disadvantage:** May require cranes, large trucks, and other heavy equipment at each stage of handling. **Advantage:** Can be handled with ordinary front-end loaders and dump trucks. Removing stem walls will reduce potential for voids when placed in cell.	Break into pieces with a nominal 3-ft maximum dimension; remove stem walls; pile in the Ash Pond until final disposal.

TABLE 5.3.4-3 Results of Modified Value Engineering: Size Reduction (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Concrete Piers Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment. Consider cost — Additional processing costs must provide sufficient benefits.	Break into any size that can be handled; place in MSA until final disposal. Break/pulverize into pieces with a nominal 3-ft maximum dimension; pile at MSA until final disposal.	**Advantage:** None. **Disadvantage:** May require cranes, large trucks, or other heavy equipment at each stage of handling. May require analysis of affect of concentrated load over liner. **Advantage:** Can be handled with ordinary front-end loaders and dump truck. Pieces are not likely to be larger than the maximum cell lift thickness.	Break/pulverize into pieces with a nominal 3-ft maximum dimension; pile in the Ash Pond until final disposal.
Masonry Blocks Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment. Consider cost — Additional processing costs must provide sufficient benefits.	Rubblize into pieces with a nominal 3-ft maximum dimension; place at the Ash Pond until final disposal.	**Advantage:** Can be handled with ordinary loaders and dump trucks.	Rubblize into wall pieces with a nominal 3-ft maximum dimension; place at the Ash Pond until final disposal.
GROUP 15 — RAILROAD RAILS			
GROUP 16 — LARGE WOOD PIECES			
Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment. Consider cost — Additional processing costs must provide sufficient benefits.	Disassemble or cut into lengths of about 8 ft or less; pile in the MSA until final disposal. Chip wood before disposal.	**Advantage:** Facilitates handling and final placement. **Disadvantage:** Higher cost to process.	Chipped and placed in the MSA wood storage area.

TABLE 5.3.4-3 Results of Modified Value Engineering: Size Reduction (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
GROUP 17 — WOOD (SPECIAL)			
Facilitate handling — Reduce pieces to manageable sizes for handling by ordinary construction equipment. Consider cost — Additional processing costs must provide sufficient benefits.	Disassemble or cut into lengths of about 8 ft or less; pile in the MSA until final disposal. Chip wood before disposal.	**Advantage:** Facilitates handling and final placement. **Disadvantage:** Higher cost to process.	Cooling tower: Chipped and placed in roll-off container and store at TSA.
GROUP 18 — MISCELLANEOUS NON-METALS - No additional alternatives evaluated.			
GROUP 19 — SPECIAL METALS - No additional alternatives evaluated.			

TABLE 5.3.4-4 Observational Method: Size Reduction

Component Specified/Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Operations
GROUP 1 -- FRIABLE AND MANMADE MINERAL FIBER				
No size reduction	Materials will be bagged and placed in sea land containers.	Additional asbestos will be encountered during demolition.	High	May require removal and bagging.
		Bags may be broken.	High	Will increase potential for exposure.
GROUP 2 — VEHICLES, ENGINES, AND SIMILAR TYPES OF MISCELLANEOUS METALS				
Equipment with sheet metal surfaces Remove wheels and other projections; remove sheet metal hoods, trunks, tops, or other covering that might hinder later filling of void spaces; flatten as appropriate; place in the MSA until final disposal.	Metal pieces randomly piled in MSA.	None expected.	Not applicable	Clean, dismantle, sort, and cap openings.
Solid Equipment Remove wheels, levers, masts, canopies, buckets, or other projections; place in the MSA until final disposal.	Metal pieces randomly piled at the MSA.	None expected.	Not applicable	Drain engine block oil and transport to Building 434.
GROUP 3 — STAINLESS STEEL				
Remove wheels, levers masts, canopies, buckets, or other projections: place in the MSA until final disposal.	Pipes, structural members, equipment and tanks to be removed using Specification 02055.	Some pipe may be bent to varying degrees. Some sheets may be bent such that binding is difficult.	High	Straighten or cut lengths as appropriate. Flatten sheets as appropriate.

TABLE 5.3.4-4 Observational Method: Size Reduction (Continued)

Component Specified/Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Operations
GROUP 4 — PIPES				
Any pipe less than 12 in. diameter Cut into relatively straight lengths of about 8 ft.	Piled randomly.	Some pipe will be bent to varying degrees.	High	No effect.
Steel pipe greater than 12 in. diameter Cut pipe into lengths of about 8 ft or less; split in half; place at the MSA until final disposal. NOTE: Only exception to 8 ft lengths of steel pipe is product process pipe 12 in. or less (size at 20 ft).	Piled randomly.	Pipe will be bent due to flattening process. Pipe may have jagged cuts due to flattening process.	High Medium	Straighten or cut lengths as appropriate. Safety concern — no significant affect.
Reinforced concrete pipe greater than 12 in. diameter Clay pipe Separate at joints; stack at the Ash Pond; fill with treated sludge during final disposal.	Pipe will be stacked or piled randomly.	None expected.	Not applicable	Not applicable.
Cast iron and clay pipe greater than 12 in. diameter Separate at joints; crush pipe to expose center; place at the MSA until final disposal.	Crushed pipe will be piled at MSA.	None expected.	Not applicable	Not applicable.
GROUP 5 — MISCELLANEOUS METALS				
Reinforcing steel and conduit Shear into lengths of about 4 ft or less; pile at the MSA.	Pile of short, tangled pieces of reinforced steel and conduit.	None expected.	Not applicable	Not applicable.

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TABLE 5.3.4-4 Observational Method: Size Reduction (Continued)

Component Specified/Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Operations
Miscellaneous metals Reduce all lengths to less than 8 ft; pile in the MSA until final disposal.	Metal pieces piled randomly at the MSA.	None expected.	Not applicable	Not applicable.
GROUP 6 — NON-METAL DEBRIS				
Non-metal debris Load debris into roll-off boxes; place loaded boxes in MSA until final disposal.	Debris will be partially broken when demolished and when loaded into roll-off boxes.	Other classes of demolition materials may end up in roll-off boxes.	High	Will require additional roll-off boxes.
HEPA vacuum dust No size reduction.	Materials will be bagged and placed in roll-off boxes exclusive of other debris.	Other debris may be thrown into roll-off boxes.	Low	May increase potential for exposure.
GROUP 7 — SHEET METAL				
Bulky sheet metal Crush bulky objects to approximately two-dimensional shapes; pile at the MSA.	Flattened sheet metal objects.	Control panels containing conduit, wire, plastics, and metal backings will not flatten much.	High	No effect.
GROUP 8 — PCB CONTAMINATED MATERIALS				
No size reduction.	To Building. 434.	None expected.	Not applicable.	Not applicable.
GROUP 9 — SELECT MATERIAL				
No size reduction.	Product material from floors and equipment surfaces to Building 434.	None expected.	Not applicable.	Not applicable.

TABLE 5.3.4-4 Observational Method: Size Reduction (Continued)

Component Specified/Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Operations
GROUP 10 — NONFRIABLE ASBESTOS-CONTAINING MATERIAL				
Nonfriable ACM (siding and sheets) Band in 4-ft high bundles at building locations; stack in MSA until final disposal.	Siding and sheets will be predominantly bundled.	Some breakage will occur. If breakage occurs subcontractor to place materials in roll-off containers. See Specification 02063. Any sharp edged ACM materials will tear poly bags, so as specified in Specification 02063 these materials to be placed in lined water tight roll-off containers.	High	Piles of broken and unbandable material to be placed at ACM. Stacked bundles to MSA.
GROUP 11 — ASBESTOS-CONTAINING MATERIAL				
Break slabs into nominal 3-ft pieces or smaller; pile at the Ash Pond and cover with soil until final disposal.	Slab sizes will vary in size from very small to about 3 ft. Rebar will require cutting or bending.	Roofing materials may separate from slab pieces.	High	Won't affect or no impact.
GROUP 12 — STRUCTURAL STEEL				
Cut steel into reasonably straight lengths of about 30 ft or 5000 lbs; remove projections to within 1 ft of steel shapes; place in MSA until final disposal.	Varying lengths of steel up to maximum 30 ft long. Ends may be twisted due to shearing. Projections will be common. Entire member may be bent and twisted due to demolition versus dismantlement.	Pieces may be bent to varying degrees.	High	30 ft or 5000 lbs. - Cut as appropriate for straighter lengths. - Further steel reduction and decon for recycling may be required at the MSA.
GROUP 13 — PLATE STEEL				
Plate steel Cut into approximately 4 ft x 8 ft sheets or smaller; place at the MSA until final disposal.	Plates will be stacked or piled randomly.	Some plates may curve more than others.	High	Smaller cut sizes may be required for very curved pieces.

TABLE 5.3.4-4 Observational Method: Size Reduction (Continued)

Component Specified/Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Operations
Metal siding, roofing, and decking Cut into approximately 4 ft x 8 ft sheets or smaller; band in 4-ft high bundles; place at the MSA until final disposal.	Bundles of banded sheet metal. Bundles will be compressible under cell waste and cover loading.	Some sheets may be bent such that binding is difficult.	High	Flatten sheets as appropriate.
GROUP 14 — RUBBLE				
Concrete piers Break/pulverize into nominal 3-ft pieces or smaller; pile at Ash Pond until final disposal.	Rubble will vary in size from very small to about 3 ft. Bells are unreinforced. Rebar in shaft will require cutting or bending.	None expected.	Not applicable.	Not applicable.
Masonry blocks Rubblize into pieces less than 3 ft nominal size; place at the Ash Pond until final disposal.	Pieces will vary in size from very small to about 3 ft. Predominant size should be around 6 in. to 12 in. Reinforcement within bond beams or cells will require cutting or removal by pulverization.	Other types of debris may become mixed with rubblized masonry blocks.	High	Pieces larger than about 3 ft should be removed, sorted, and reduced as required. The smaller pieces can be handled as rubble.
GROUP 15 — RAILROAD RAILS				
Rails.	Rails will be stacked.	None expected.	Not applicable.	Not applicable.
GROUP 16 — LARGE WOOD PIECES				
Disassemble or cut into lengths of about 8 ft or less; pile in the MSA or Mulch Pile Area (chemically treated wood will also be mulched).	Wood piled randomly at the MSA.	Other types of debris, such as bolts, brackets, wallboard may be mixed with wood.	High	No effect.

TABLE 5.3.4-4 Observational Method: Size Reduction (Continued)

Component Specified/Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Operations
GROUP 17 — WOOD (SPECIAL) - Cooling tower				
Mulched and loaded into roll-off boxes.	All material to be placed at the TSA.	None expected.	Not applicable.	Not applicable.
GROUP 18 — MISCELLANEOUS NON-METALS				
Trash and miscellaneous non-metal.	Placed in roll-off boxes at the MSA.	None expected.	Not applicable.	Not applicable.
GROUP 19 — SPECIAL METALS				
No size reduction.	Aluminum and copper to be stored at the MSA. Lead to be stored at the TSA.	None expected.	Not applicable.	Not applicable.

TABLE 5.3.5-1 Results of Modified Value Engineering: Classifier

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Mechanical reliability. Ease of operation. Cost (high, moderate, low). Volume capacity (high, moderate, low). Maintenance. Mobility. Handle wide range of particle size.	Vibrating screen.	**Advantages:** Mechanically reliable. Ease of operation. High volume capacity. Equipment can be moved. Will handle wide range particle size. **Disadvantages:** High cost. High maintenance.	Rotating screen trommel. The trommel will handle a higher throughput than the design capabilities. If unit is designed for 100 tph, it can be increased to 150 tph, while vibrating screens do not have the latitude.
	Stationary west sizing screen.	**Advantages:** Requires little operator attention. Low cost. Low maintenance. **Disadvantages:** Mechanically reliable - tend to plug and bind. Low volume capacity. Install in storage device. Limited on solids particle size.	
	Rotating screen trommel.	**Advantages:** Mechanically reliable. Ease of operation. High volume capacity. Equipment can be moved. Will handle wide range particle size. **Disadvantages:** High cost. High maintenance.	

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TABLE 5.3.5-2 Results of Modified Value Engineering: Storage

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Volume capacity (high, moderate, low). Construction costs (high, moderate, low). Radon control (poor, good). Installation mobility.	Agitated-storage tank.	**Advantages:** Good radon control. Tank can be moved. **Disadvantages:** Low volume capacity. High construction cost.	Storage tank.
	Storage basin.	**Advantages:** High volume capacity. Low construction cost. **Disadvantages:** Poor radon control. Cannot move basin.	

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TABLE 5.3.5-3 Results of Modified Value Engineering: Flocculants

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Toxicity. Ease of handling. Availability. Compatibility. Corrosive properties. Storage cost. Reagent.	Organic polymers.	**Advantages:** Low toxicity. Ease to handle. Available. Good compatibility. Noncorrosive. Low storage cost. **Disadvantages:** High reagent cost.	Organic polymers.
	Coagulants (inorganic salts).	**Advantages:** Availability. Low reagent cost. **Disadvantages:** High toxicity. Ease of handling. Poor compatibility. Corrosive. High storage costs.	

TABLE 5.3.5-4 Results of Flocculant Tests on Raffinate Sludge

Item	Pit 1	Pit 2	Pit 3	Pit 4
Water content of sludge, % by wt.	70	68	73	50
Weight density, g/ml	1.26	1.28	1.22	1.50
Flocculated slurry: 14.4% solids			1,180 ppm of floc	
16.9% solids			1,952 ppm of floc	
22.0% solids			2,180 ppm of floc	
Flocculated slurry: 16.9% solids				100 ppm of floc
21.0% solids				135 ppm of floc
26.0% solids				150 ppm of floc
Avg. diameter of thickener, 15% solids, unflocculated slurry			400 ft	375 ft
Area of thickener, 15% solids, unflocculated slurry			125,000 ft²	115,000 ft^2
Avg. diameter of thickener, 15% solids, flocculated slurry			60 ft	65 ft
Area of thickener, 15% solids, flocculated slurry			3,450 ft^2	3500 ft^2

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TABLE 5.3.5-5 Results of Modified Value Engineering: Blender/Mixer

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Mechanical reliability. Volume capacity. Mix/blend ability. Ease of addition of radon adsorption equipment.	Rotary tank agitated mixer/blender.	**Advantages:** Mechanical reliability. High volume. Radon equipment. **Disadvantages:** Mix/blend.	Auger/mixer.
	Auger/mixer.	**Advantages:** Mechanical reliability. High volume. Radon equipment. **Disadvantages:** Mix/blend.	

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TABLE 5.3.5-6 Result of Modified Value Engineering: Thickeners

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Mechanical reliability. Volume capacity. Equipment cost. Ease of operation. Need for instrument control. Ability handle wide range of solids content.	Standard slurry tank/rake type. Inclined plates. High-capacity thickener.	**Advantages:** Mechanically reliable. Large volume. Moderate equipment cost. Easy to operate. Little instrumentation. **Disadvantages:** Limited range. **Advantages:** Mechanically reliable. Easy to operate. **Disadvantages:** Small volume. High costs. Need instrumentation. Limited range. **Advantages:** Mechanically reliable. Large volume. Moderate cost. Easy to operate. Wide range. **Disadvantages:** Need instrumentation.	High-capacity thickener.

TABLE 5.3.5-7 Results of Modified Value Engineering: Dewatering Methods

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Ease of operation. Volume capacity. Generate off-gas. Energy consumption. Applicability. Equipment cost. Continuous.	Mechanical.	**Advantages:** Easy to operate. High volume capacity. No off gas. Low energy cost. Good applicability. Continuous. **Disadvantages:** Moderate cost.	Mechanical.
	Chemical.	**Advantages:** Low energy cost. Low cost. **Disadvantages:** Difficult to operate. Moderate to low volume. Off gas generated. Poor applicability. Batch.	
	Thermal.	**Advantages:** Easy to operate. High volume capacity. Good applicability. Continuous. **Disadvantages:** High off gas generated. High energy cost. Very high cost.	

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TABLE 5.3.5-8 Observational Method: For Dewatering

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Mechanical	Deviation of physical properties of raffinate sludge.	Would probably not achieve water removal objectives.	High	Yes. More control instrumentation in overall process.
Chemical	Heat of hydration will cause lumpy and hard rock-like solids.	Premature solidification of the sludges.	High	Yes. A crusher and grinder will have to be incorporated in the circuit.
Thermal	Off-gas regeneration and high particulate (solids) carry-over.	Increase solids loss.	High	Yes. Design and off-gas treating facility to include bag house collection of solid particles.

TABLE 5.3.5-9 Data Needs: For Dewatering

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Mechanical	The slurry consistency or composition change over a wide range.	What steps should be taken to minimize these conditions?	Take timely samples for total slurry solids.
		Where along the process train should emphasis be made to optimize control?	Take samples at each point of the inlet and discharge size of the process equipment.
Chemical	The sludge will form a hard lumpy rock-like solid.	How best to solve this problem and what type equipment is best needed?	The water content needs to be determined before the chemical reagents are added.
Thermal	During the thermal drying stage, gas/air mixture along with vapor and fumes and fine particles will be carried off.	Will the off gas be (1) toxic or (2) corrosive?	Take samples of the off-gas and analyze for acid gas.

TABLE 5.3.5-10 Alternatives Evaluation: Dewatering

Project WSSRAP - Dewatering Task 730 Study Item

Function Being Analyzed Dewatering - CSS Plant

No.	Selected Alternatives*	Advantages	Disadvantages	Idea Rating
1) 2) 3) 4) 5) 6) 7) 8)	Centrifuge (1) Cycloning (1) Freeze drying (2) Thickener (3) Thermal drying (4) Filter press (4) Screw press (4) Microwave (4)	• Results indicate relative preference of alternative methods but there is no assurance that any one method will work on the raffinate. • Thermal drying, microwave, and F-D processes produce a concentration of soil materials that may adversely impact a) off-gas system in melter and b) melter refractory. • Probable water reduction techniques will be made up of several of the processes evaluated. • Physical methods are preferred on a qualitative basis by the MVE team.		

*Note: Additional investigations required are listed on "Additional Items for Study" page.

TABLE 5.3.5-11 Results of Modified Value Engineering: Mechanical Dewatering - CSS

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Mechanical reliability. Ease of operation. Maintenance. Ability to dewater. Continuous operation. Volume capacity. Filter aid. Hydraulic load. Energy.	Centrifuge.	**Advantages:** Mechanically reliable. Ease of operation. Continuous. No filter aid. **Disadvantages:** High maintenance. Moderate ability to dewater. Low volume. Moderate hydraulic. High energy.	Belt press.
	Screw press.	**Advantages:** Mechanically reliable. Ease of operation. Low maintenance. Good ability to dewater. Continuous. No filter aid. Low energy. **Disadvantages:** Low volume. Moderate hydraulic.	
	Belt press.	**Advantages:** Mechanically reliable. Ease of operation. Low maintenance. Good ability to dewater. Continuous. Large volume. No filter aid. Low hydraulic. Low energy.	

TABLE 5.3.5-11 Results of Modified Value Engineering: Mechanical Dewatering - CSS (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Vacuum filter.	**Advantages:** Mechanically reliable. Ease of operation. Moderate ability to dewater. Continuous. **Disadvantages:** High maintenance. Moderate volume. Need filter aid. Moderate hydraulic. High energy.	
	Leaf and frame press.	**Advantages:** Mechanically reliable. Ease of operation. Good ability to dewater. No filter aid. **Disadvantages:** High maintenance. Batch. Low volume. High hydraulic. High energy.	

TABLE 5.3.5-12 Results of Modified Value Engineering: Mechanical Dewatering - VIT

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Mechanical reliability. Ease of operation. Maintenance. Ability to dewater. Continuous operation. Volume capacity. Filter aid. Hydraulic load. Energy.	Centrifuge.	**Advantages:** Mechanically reliable. Ease of operation. Continuous. No filter aid. **Disadvantages:** High maintenance. Moderate ability to dewater. Low volume. Moderate hydraulic. High energy.	Belt expressor press.
	Screw press.	**Advantages:** Mechanically reliable. Ease of operation. Low maintenance. Good ability to dewater. Continuous. No filter aid. Low energy. **Disadvantages:** Low volume. Moderate hydraulic.	
	Belt expressor press.	**Advantages:** Mechanically reliable. Ease of operation. Low maintenance. Good ability to dewater. Continuous. Large volume. No filter aid. Low hydraulic. Low energy.	
	Vacuum filter.	**Advantages:** Mechanically reliable. Ease of operation. Moderate ability to dewater. Continuous. Moderate hydraulic. **Disadvantages:** High maintenance. Moderate volume. Need filter aid. High energy.	

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TABLE 5.3.5-12 Results of Modified Value Engineering: Mechanical Dewatering - VIT (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Leaf and frame press.	**Advantages:** Mechanically reliable. Ease of operation. Good ability to dewater. No filter aid. **Disadvantages:** High maintenance. Batch. Low volume. High hydraulic. High energy.	

TABLE 5.3.5-13 Results of Modified Value Engineering: Radon Emission Control

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Adsorption efficiency. Volume capacity. Cost. Regeneration cycles. Spent materials.	Vapor carbon adsorber.	**Advantages:** High adsorption efficiency. **Disadvantages:** Low capacity. High costs. Requires many regenerations. Need to dispose of spent carbon.	Vapor phase carbon adsorber.
	Molecular sieve.	**Disadvantages:** High pressure. Technology. Limited removal technology.	

TABLE 5.3.5-14 Observational Method: Radon Emission Control

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Trommel classifier	If the trash and debris in the raffinate sludge exceed 1 in. size while dredging the pits.	Damage the screens and shut down the operation.	High	None. This will increase the maintenance on the system, more down-time.
	If clay liner breaks up during dredging and mixes with the raffinate sludges.	Will cause balls and lumps, and will blind and plug the screens.	High	Yes. Will have to design a self-cleaning high-pressure water spray.
Agitated-storage tank	Clay liner materials are mixed with raffinate sludge.	Change the physical characteristics of the slurry.	High	Yes. Add agitator and slope bottom of storage tank.
Flocculant	During dredging any drastic chemical or physical changes in the raffinate sludge slurry.	The dosage rates would change and the flocculant ability to flocculate the solid particles would change.	High	Yes. More controls instrumentation is needed to monitor pH, density, and solids content.
Auger/mixer	Due to high clay liner materials, the flocculent will not make intimate contact with the solids particles.	This would result in a poorly flocculated solids particle.	High	None. The mixer speed can be changed along with the pitch on the auger blades.
Carbon adsorber	Due to the slow speed of the auger/mixer while the flocculant is added.	The radon gas may be entrained in the slurry.	High	Yes. Will need to add blower to pull gas out of the auger/mixer and desiccant dryer for the water carryover.
High-capacity thickener	A poorly flocculated slurry.	Require longer settling time resulting in less dense underflow with high solids carryover in overflow.	Medium	None. Change operating conditions of thickener.

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TABLE 5.3.5-14 Observational Method: Radon Emission Control (Continued)

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Belt filter press (CSS)	Lumps and balls of clay liner material carried through the process.	Resulting in a tacky-sticky cake and decreases the water removal efficiency.	Medium	None. Increase belt rollers.
Belt expressor press (VIT)	Lumps and balls of clay liner material carried through the process.	Resulting in a tacky-sticky cake and decreases the water removal efficiency.	Medium	None. Increase belt rollers.
Materials Classifier	Dredge shut-down. Break in the dredge screen system. Radon emission.	No feed to process. Oversized materials break through and plug or overload classifier. Due to agitation of water and solids radon gas will escape.	Moderate Moderate High	None. Yes, design additional classifier capacity. Yes, radon control equipment be added.
Radon Control Device	During dredging, classifying and raffinate sludge storage radon gas will escape.	The safety and health standards will be be violated due to excessive radon emission, resulting in shuting down of the operation.	High	The materials classifier will have to be totally enclosed. The storage device and mixing device will need manifolding into a radon control device.
Agitated Storage Device	Dredge digs into the clay liner. Classifier screen is damaged or torn. Radon emission.	Change consistency of slurry, settled materials will form a thick cake of solids at bottom of device. Plug up pipes and foul pumps. During filling and emptying, a closed storage device, radon will escape.	Moderate Moderate High	Yes, incorporate an agitator. Yes, install screens in pipeline. Yes, install radon control equipment.

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TABLE 5.3.5-14 Observational Method: Radon Emission Control (Continued)

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Mixing Device	Large amounts of clay-like materials are introduced into the system.	Change the flocculating characteristics and dosage addition to the slurry.	Moderate	Yes, design the reagent addition system to handle any process feed changes.
Reagents	Addition rate variation.	Solids will not flocculate.	Low	Yes, design the reagent addition system to handle any process feed changes.
Thickening Device	The feed from the mixing device does not have adequate reagent added.	The solid separation phase will be delayed. Settling rates will be slow. High solids content in overflow.	Moderate Moderate Moderate	Yes, design thickener with variable speed rake, add well flocculant wier to thickener. Same as above. Same as above.
Dewatering Devices, Both for CSS and VIT	Unflocculated solids report to dewatering.	Will not achieve water removal goals.	Moderate	Yes, addition stage of dewatering will need to be added to device.

TABLE 5.3.5-15 Data Needs: Radon Emission Control

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Materials Classifier	Shut-down of equipment due to damage and plugging.	How will the dredge operation be monitored? How best to handle the breakthrough of oversized trash and debris. Will agitation of slurry cause radon to escape?	Sampling of dredged slurry. Radon sampling and detection device.
Radon Control Device	If radon emissions exceed the H&S standard.	How effective is radon removal of the vent gases to the atmosphere? Will radon escape during each step of the operation, (a) classifying, (b) storage and (c) mixing.	Collect samples from the discharge of the radon control device. Collect samples from each piece of process equipment.
Agitated Storage Device	Selection of agitated storage device and materials of construction.	Will stored slurry corrode the storage device?	Take samples and monitor pH.
Mixing Devices	Clay-bottom materials mixing with the raffinate sludges.	How will this affect reagent addition? What sort of flocculated solids can be expected?	Take daily samples of slurry and check its flocculating properties.
Reagent(s)	Addition feed sites needed for the process.	How can the reagent be best optimized and what point should it be added? Will different type of reagent be needed for each raffinate sludge?	Same as above.

TABLE 5.3.5-15 Data Needs: Radon Emission Control (Continued) 030394

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Thickening Device	High clay-bottom materials will cause the size and rate drive system to be change.	How will the solids settling rates and flocculated material behave? How much total suspended solids (TSS) will be discharged in the overflow?	Take batch samples and run flocculating and settling tests. Task samples and run TSS.
Dewatering Devices for Both CSS and VIT	The water content of the filter cake may not meet the CSS or VIT plant feed criteria.	How can the filter cake, water content be optimize? (Not enough water removed) Same as above? (Too much water removed)	Samples be taken and analyzed for water.

TABLE 5.3.6-1 Results of Modified Value Engineering: Decontamination

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Worker Health and Safety. Effectiveness. Labor intensity minimization. Residual waste minimization.	Hydroblasing.	**Advantages:** More effective than CO_2 blasting. Salvage resource. Cell reduction. **Disadvantages:** Residual waste. Lower worker health and safety.	No action was the preferred alternative. CO_2 blasting was second in preference, but required pilot- or bench-scale testing. Liquid abrasive or grit blasting was the third preferred alternative.
	Grit blasting with recovery system.	**Advantages:** More effective than CO_2. Salvage resource. Cell reduction. **Disadvantages:** Residual waste. Lower worker health and safety.	
	Hydrometallurgy.	**Advantages:** Better work health and safety. **Disadvantages:** Ineffective.	
	Liquid abrasive blasting.	**Advantages:** More effective than CO_2. Salvage resource. Cell reduction.	
	Carbon dioxide blasting.	**Advantages:** Good worker health and safety. No residual waste. Salvage resource. Cell reduction. **Disadvantages:** Requires testing. Must meet release criteria.	

TABLE 5.3.6-2 Radiological Surface Contaminant Release Levels

Radionuclides[2]	Allowable Total Residual Surface Contamination (dpm/100 cm^2)		
	Average[3,4]	Maximum[4,5]	Removable[4,6]
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129.	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-133.	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay products.	5,000[7]	15,000[7]	1,000[7]
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000	15,000	1,000

1 As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

2 Where surface contamination by both alpha and beta-gamma-emitting radionuclides exists, the limits established for alpha and beta-gamma emitting radionuclides should apply independently.

3 Measurements of average contamination should not be averaged over an area of more than 1 m^2. For objects of less surface area, the average should be derived for each such object.

4 The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

5 The maximum contamination level applies to an area of not more than 100 cm^2.

6 The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper while applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

7 Specified for alpha emissions.

* From DOE Order 5400.5

TABLE 5.3.7-1 Treatment Alternatives for Hazardous Wastes Stored in Building 434

Hazardous Waste Code	Waste Description [Technology-Based or Concentration-Based Standard]	Alternative Treatment Process
D001	Ignitables Oxidizers $KMnO_4$, $NaNO_3$, $U\text{-}ThNO_3$, $CuNO_3$ [Deactivation, chemical reduction, incineration].	Deactivate in SWTT 1.
	Chlorinated hydrocarbons < 10% [Organic recovery, incineration, chemical oxidation].	Remove organics with carbon adsorption using the MSWTS. Add solids into CSS or VIT plant feedstock to stabilize.
	> 10% [Incineration, fuels substitution, organic recovery].	Incinerate at Oak Ridge.
	> 90% (liquids only) [Incineration, fuels substitution, organic recovery].	Energy recovery at Oak Ridge.
D002	Corrosives. Acids (with or without heavy metals) [Recovery, neutralization, incineration].	Deactivate with caustics using the MSWTS and chemically stabilize heavy metals. Direct solids to CSS or VIT plant.
	Hydroxides (with or without heavy metals). [Neutralization, incineration].	Deactivate with acids using the MSWTS and chemically stabilize heavy metals. Direct solids to CSS or VIT plant.
D003	Reactives. Cyanide. [Total CN $\geq$ 590 mg/kg; BDAT = alkaline chlorination, wet air oxidation, or electrolytic oxidation].	Deactivate with sodium hypochlorite or potassium permanganates using the MSWTS. Direct solids to CSS or VIT plant.
	Mg and Cd shavings, Ca, Na_2SO_3 [Incineration, chemical oxidation, chemical reduction].	Deactivate with controlled reaction with water using the MSWTS. Direct solids to CSS or VIT plant.
D004	Arsenic [TCLP $\geq$ 5 ppm; BDAT = vitrification or chemical precipitation].	Chemically treat in the MSWTS and add solids into CSS or VIT plant feedstock to stabilize and solidify.
D005	Barium (salts) [TCLP $\geq$ 100 ppm; BDAT = stabilization].	Chemically treat in the MSWTS and add solids into CSS or VIT plant feedstock to stabilize and solidify.
D006	Cadmium [TCLP $\geq$ 1 ppm; BDAT = stabilization, metal recovery].	Chemically treat in the MSWTS and/or add solids into CSS or VIT plant feedstock to stabilize and solidify.

TABLE 5.3.7-1 Treatment Alternatives for Hazardous Wastes Stored in Building 434 (Continued) 030894

Hazardous Waste Code	Waste Description (Technology-Based or Concentration-Based Standard)	Alternative Treatment Process
D007	Chromium (tars, salts, paints) [TCLP ≥ 5 ppm; BDAT = chromium reduction, stabilization or precipitation].	Chemically treat in the MSWTS and/or add solids into CSS or VIT plant feedstock to stabilize and solidify.
D008	Lead (salts) [TCLP ≥ 5 ppm; BDAT = stabilization, chemical precipitation].	Chemically treat with caustics in the MSWTS and add solids into CSS or VIT plant feedstock to stabilize and solidify.
	Lead (elemental) [macroencapsulation].	Alt. 1 Encapsulate on site or off site. Alt. 2 Obtain waiver to stabilize in CSS plant.
D009	Mercury (total Hg < 260 mg/kg) [TCLP ≥ 0.2 ppm; BDAT = acid leaching, chemical oxidation or precipitation].	Chemically treat in the MSWTS and/or add solids into CSS or VIT plant feedstock to stabilize and solidify.
	Mercury (total Hg ≥ 260 mg/kg) [Incineration].	Incinerate at Oak Ridge.
	Mercury (elemental) [Amalgamation].	On-site amalgamation with on-site CSS or VIT treatment plant.
D010	Selenium [TCLP ≥ 5.7 ppm; BDAT = stabilization or precipitation].	Chemically treat in the MSWTS and/or blend solids into CSS or VIT plant feedstock.
D011	Silver [TCLP ≥ 5 ppm; BDAT = stabilization, chemical precipitation or recovery].	Deactivate with chemical precipitation in the MSWTS and blend solids into CSS or VIT feed to stabilize and solidify.
D016	Herbicide, Characteristic 2,4-D [Total 2, 4-D ≥ 10 ppm; BDAT = incineration or chemical oxidation].	Incinerate at Oak Ridge.
D017	Herbicide, Characteristic, 2,4,5-TP [Total 2, 4, 5-TP ≥ 7.9 ppm; BDAT = incineration or chemical oxidation].	Incinerate at Oak Ridge.
D018	Benzene, Characteristic <10%	Deactivate liquids with carbon adsorption in the MSWTS and blend solids into CSS or VIT feedstock to stabilize and solidify.
	>10%	Incinerate at Oak Ridge.
	>90% [No treatment standards yet promulgated].	Use as boiler fuel at Oak Ridge.

TABLE 5.3.7-1 Treatment Alternatives for Hazardous Wastes Stored in Building 434 (Continued) 030994

Hazardous Waste Code	Waste Description [Technology-Based or Concentration-Based Standard]	Alternative Treatment Process
D022	Chloroform, Characteristic. <10%	Deactivate liquids with carbon adsorption in the MSWTS and blend solids into CSS or VIT plant feedstock to stabilize and solidify.
	>10%	Incinerate at Oak Ridge.
	>90% [No treatment standards yet promulgated].	Use as boiler fuel at Oak Ridge.
D028	1,2-Dichloroethylene, Characteristic. <10%	Deactivate liquids with carbon adsorption in the MSWTS and blend solids into CSS or VIT plant feed to stabilize and solidify.
	>10%	Incinerate at Oak Ridge.
	>90% [No treatment standards yet promulgated].	Use as boiler fuel at Oak Ridge.
D029	1,1-Dichloroethylene, Characteristic. <10%	Deactivate liquids with carbon adsorption in the MSWTS and blend solids into CSS or VIT plant feed to stabilize and solidify.
	>10%	Incinerate at Oak Ridge.
	>90% [No treatment standards yet promulgated].	Use as boiler fuel at Oak Ridge.
D035	Methyl Ethyl Ketone, Characteristic. <10%	Deactivate liquids with carbon adsorption in the MSWTS and blend solids into CSS or VIT plant feed to stabilize and solidify.
	>10%	Incinerate at Oak Ridge.
	>90% [No treatment standards yet promulgated].	Use as boiler fuel at Oak Ridge.
D039	Tetrachloroethylene, Characteristic. <10%	Deactivate liquids with carbon adsorption in the MSWTS and blend solids into CSS or VIT plant feed to stabilize and solidify.
	>10%	Incinerate at Oak Ridge.
	>90% [No treatment standards yet promulgated].	Use as boiler fuel at Oak Ridge.

TABLE 5.3.7-1 **Treatment Alternatives for Hazardous Wastes Stored in Building 434 (Continued)** 030894

Hazardous Waste Code	Waste Description [Technology-Based or Concentration-Based Standard]	Alternative Treatment Process
D040	Trichloroethylene, Characteristic. $<10\%$ $>10\%$ $>90\%$ (No treatment standards yet promulgated).	Deactivate with carbon adsorption in the MSWTS and blend solids into CSS or VIT plant feed to stabilize and solidify. Incinerate at Oak Ridge. Use as boiler fuel at Oak Ridge.
D098	Used Oil [MDNR]. $<10\%$ $>10\%$ $>90\%$ (State characteristic hazardous waste, no treatment standards].	Deactivate liquids with carbon adsorption to the MSWTS and blend solids into CSS or VIT plant feed to stabilize and solidify. Incinerate at Oak Ridge. Use as boiler fuel at Oak Ridge.
U228	Trichloroethylene, Listed. (BDAT = wet air oxidation followed by carbon adsorption and/or incineration].	Alt. 1 Apply and pursue "off-site waste release criteria" for container and contents. Recycle contents or treat contents as hazardous waste and dispose of at RCRA facility. Alt. 2 Incinerate as mixed waste at Oak Ridge. Alt. 3 Use as boiler fuel at Oak Ridge.
P120	Vanadium Pentoxide, Listed. (LDR specified technology for non-wastewater is stabilization) [BDAT (for wastewater only) = chemical precipitation].	Alt. 1 Apply and pursue "off-site waste release criteria" for container and contents. Recycle contents or treat contents as hazardous waste and dispose of at RCRA facility. Alt. 2 Pursue variance to stabilize at the WSSRAP and ship stabilized vanadium pentoxide to commercial facility (e.g., Envirocare in Clive, Utah). Alt. 3 Continue to store on site until DOE Nevada or commercial facility provides treatment and disposal, expected in 1994. Alt. 4 Incinerate as mixed waste at Oak Ridge.

NOTE: Reference to "Oak Ridge" refers to DOE and commercial sites located in Oak Ridge, Tennessee.

TABLE 5.3.7-2 Recommended Treatment Alternative for Containerized Hazardous Wastes Stored in Building 434

Waste Description [Hazardous Waste Codes]	Alternative Treatment Process	WITS Container Number (Estimated Mass)
Oxidizers (D001).	Deactivate in SWTP 1.	0255, 0384, 0456, 0457, 0496, 0518, 0519, 0871, 1408, 1412 (4,000 lb)
Hydrocarbons, Chlorinated and Nonchlorinated (D001, D018, D022, D028, D029, D035, D039, D040 and D098).		
<10%	Remove organics with carbon adsorption utilizing the MSWTS. Blend solids into CSS or VIT plant feed to stabilize and solidify.	0429, 0647, 0648, 0650, 0652, 0654-0659, 0662, 0663, 0665, 0673, 0675, 0677, 0684-0687, 0690-0692, 1441, 1507, 1516-1525, 1597-1637, 1647, 1663, 1669, 1783 (20,800 lb)
>10%	Incinerate at Oak Ridge.	1426, 1481, 1649 (1,200 lb)
>90%	Energy Recovery at Oak Ridge.	0309, 0394, 0395, 0398, 0400-0402, 0405, 0407, 0411, 0418-4020, 0426, 0427, 0430, 0436, 0438, 0501-0507, 0509, 0854, 0857, 1317, 1334, 1344, 1347, 1368, 1479-1480, 1698, 1700 (11,200 lb)
Acids, Hydroxides and Metals (D002, D004, D005, D006, D007, D008 salts, D009 if Hg < 260 mg/kg, D010 and D011).	Deactivate and/or treat in the MSWTS. Blend solids into CSS or VIT plant feed to stabilize and solidify.	0256-0258, 0266, 0288-0306, 0308, 0316, 0323-0359, 0491, 0508, 0581, 0592, 0627, 0628, 0645, 0851, 0861-0863, 1315, 1316, 1320, 1321, 1324, 1325, 1331, 1362, 1363, 1375, 1376, 1423, 1449, 1565, 1566, 1577, 1588, 1673-1676, 1706 (37,200 lb)

TABLE 5.3.7-2 Recommended Treatment Alternative for Containerized Hazardous Wastes Stored in Building 434 (Continued)

Waste Description [Hazardous Waste Codes]	Alternative Treatment Process	WITS Container Number (Estimated Mass)
Reactives (D003).	Deactivate with the MSWTS. Direct solids to CSS or VIT.	0380-0383, 0499, 1328, 1380-1385, 1404, 1407, 1454-1456, 1658, 1689, 1705 (6,400 lb)
Elemental Lead (D008).	Encapsulate on site. Direct solids to CSS or VIT treatment plant.	0838, 1369-1371, 1395-1398, 1426, 1567, 1595, 1679 (4,600 lb)
Elemental Mercury (D009).	Amalgamate on site. Direct solids to CSS or VIT treatment plant.	1409 (400 lb)
Herbicide (D016 and D017).	Incinerate at Oak Ridge.	0321, 1402, 1403, 2012 (1,600 lb)
Listed Wastes (U228 and P120).	Apply and pursue "off-site waste release criteria" for container and contents. Recycle contents or treat contents as hazardous waste and dispose of at RCRA facility.	0872, 0873, 1400 (1,200 lb)

NOTE: Reference to "Oak Ridge" refers to DOE and commercial sites located in Oak Ridge, Tennessee.

TABLE 5.3.7-3 Treatment Alternatives for PCB-Contaminated Materials

Waste Description [Treatment Standard]	Alternative Treatment Process	WITS Container Number (Estimated Mass)
Liquids and Sludges. [Incineration].	Alt. 1 On-site dehalogenation with off-site energy recovery. (EPA waiver required.) Alt. 2 Incinerate at Oak Ridge or vitrify at the WSS.	0415, 0428, 0433, 0435, 0610, 0859, 1510 (3,800 lb)
Soils. [Incineration or TSCA landfill].	Alt. 1 On-site dehalogenation with on-site CSS or VIT. (EPA waiver required.) Alt. 2 Incinerate at Oak Ridge or vitrify at the WSS.	0432, 0874, 0875, 1526-1530 (3,200 lb)
Transformers and Capacitors. [Incineration or TSCA landfill].	Alt. 1 Decontaminate transformer and capacitor shell to satisfy "off-site waste release criteria" and dispose shell and contents at TSCA commercial incinerator. Alt. 2 Vitrify at the WSS.	1410, 1489, 1450 (2,500 lb)

NOTE: Reference to "Oak Ridge" refers to DOE and commercial sites located in Oak Ridge, Tennessee.

TABLE 5.3.7-4 Treatment Alternatives for Arsenic-Contaminated Cooling Tower Wood, Water Treatment Plant Sludges, and Tributyl Phosphate Liquids Tainted with PCBs

Waste Description [Treatment Standard]	Alternative Treatment Process (Estimated Mass)
Arsenic wood residue [Incineration].	Blend solids into CSS or VIT plant feed. (47 T).
Water treatment plant sludges [Standard not known until waste characterized].	Blend solids into CSS or VIT plant feed. (800 lb/day).
Tributyl phosphate liquids with PCBs. [Incineration].	Alt. 1 On-site dehalogenation and use TBP as defoamer in CSS process. Alt. 2 Incinerate at Oak Ridge. (63,000 lb).

NOTE: Reference to "Oak Ridge" refers to DOE and commercial sites located in Oak Ridge, Tennessee.

TABLE 5.4-1 Results of Modified Value Engineering: Removal and Remediation of Temporary Support Facilities

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Uncontaminated materials only. Public safety, health, and welfare. Reduce cell volume. Salvage and maximize reuse of materials. Minimize overall cost. Stringent off-site release criteria.	No action. Remove and place in cell. Remove and release off site. Rubblize subgrade materials in place and cover with topsoil. Remove subgrade materials, rubblize, and reuse as aggregate for road base or drainage riprap.	**Advantages:** Removes materials from original location. Public safety and health is maintained. Minimizes cell volume. Maximizes reuse of materials. Minimizes overall cost. Minimizes stringent off-site release inspections. **Disadvantages:** Does not facilitate site remediation. Increases cell volume with uncontaminated materials. Costly inspection and testing of materials based on stringent off-site release criteria. Does not provide flexibility for future property use.	Remove subgrade materials, rubblize, and reuse for road base or drainage riprap.

TABLE 5.4-2 Observational Method: Removal and Remediation of Temporary Support Facilities

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurence	Affect on Design
Remove subgrade materials, rubblize, and reuse for road base or drainage riprap.	Materials are not contaminated.	Materials are contaminated.	Medium	Materials must be placed in cell or shipped off site for disposal at an approved site. Materials for road base and drainage riprap must be obtained from other sources.
	Materials are suitable for use as road base or drainage riprap.	Materials are not suitable for use as road base or drainage riprap.	Low	Materials must be placed in cell or shipped off site for disposal at an approved site. Materials for road base and drainage riprap must be obtained from other sources.

TABLE 5.4-3 Results of Modified Value Engineering: Site Road Systems

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
		Advantages:	
30-yr serviceability.	Road widths one lane.	Adequate travel width. Minimizes cost.	One-lane road width.
Low maintenance.	Road widths two lanes.	Generous travel width. Unnecessary cost.	
Minimize cost.	Asphalt road surface.	Serviceable. Low maintenance. Moderate cost.	
	Concrete road surface.	Serviceable. Low maintenance. High cost.	Gravel road surface.
	Gravel road surface.	Serviceable. Moderate maintenance. Low cost.	
	Drainage culverts.	Serviceable. Low maintenance. Moderate cost.	Drainage culverts.
	Road dip drainage.	Serviceable. High maintenance. Moderate cost.	

TABLE 5.4-4 Observational Method: Site Road Systems

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
One-lane road width.	Sufficient travel width.	None.		
Gravel road surface.	30-year life with moderate maintenance. Supports vehicle loads.	Road deterioration in various locations.	Moderate	Aggregate sized to minimize erosion.
Drainage culverts.	30-year life with minimal maintenance.	Culvert fails and washes out.	Low	Inlet protection provided to reduce possible erosion.
	Maintains design storm flows.	Flows exceed the design storm event.	Low	Flows will top the road until storm dissipates.

TABLE 5.4-5 Road Minimum Design Requirements

Items	Road Type	
	Entrance	Cell
Surface Width (ft)	24	12
Shoulder Width (ft)	4	< 2
Asphalt Thickness (in.)	*	*
Aggregate Surfacing or Base Material (in.)	*	*
Traffic Loading (pounds)	2000	2000
Maximum Gradient (%)	5	8
Design Speed (mph)	20	20
Min. Vertical Curve (ft)	*	*

* To be determined during final design.

TABLE 5.4-6 Results of Modified Value Engineering: Revegetation

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Minimize maintenance. Provide erosion protection. Aesthetics. Ease of establishment.	Mixed stand of native, warm-season perennial plants, primarily grasses with minor amounts of native or introduced legumes (clovers, vetches).	**Advantages:** Known adaptability in this part of the country. Long-lived and persistent. Ability to grow in a wide variety of soils. Once established, will maintain themselves in a vigorous condition. Provide better erosion protection due to more extensive root system and more dense aboveground cover than introduced grass. Provide better native wildlife habitat than introduced grass plantings. Require less fertilizer to establish than introduced grasses; do not need continual fertilizer or insecticide application for maintenance. More drought tolerant than introduced grasses. Because they are native to this area, they are further along the successional continuum toward native prairie or hardwood forest. Because the disposal cell cover is planned to be planted with native grasses, planting native grasses in the surrounding landscape will minimize the visual impact of the disposal cell. Will provide a buffer around the disposal cell which will retard weedy invasion. **Disadvantages:** Take longer to initially establish than cool-season grasses. Noncompetitive cover or mulch must be provided to provide erosion protection until plants can establish. May require scorching in the spring for stand establishment (potential air quality issue).	Establishment of mixed stand of native grasses, with minor amounts of native or introduced legumes (clovers, vetches).
	Introduced, cool-season perennial plants, primarily grasses with minor amounts of native or introduced legumes (clovers, vetches).	**Advantages:** Establishment techniques well established. Variety of cultivars to select from to meet specific site requirements. May respond to mowing better than native grasses when mowing is necessary (as along roads). **Disadvantages:** Require higher soil fertility conditions than native grasses. Less tolerant of drought conditions than native grasses. Higher maintenance requirements that native grasses (fertilizing, mowing). Provide less erosion control than native grasses, due to shallower roots. May be more prone to invasion by weedy species than native grasses.	

TABLE 5.4-7 Results of Modified Value Engineering: Groundwater Monitoring

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Practical and technically suitable - demonstrated technology, must be accurate and precise. Simplicity - must be easy to construct using standard installation techniques. Longevity - system must operate for the duration of monitoring and maintenance phases. Effect on cell integrity. Interference with the natural system.	Installation of monitor wells.	**Advantages:** Meets regulatory requirements. Can be used spatially and temporally. Can detect contaminant changes prior to groundwater reaching point of compliance repetitively. Can monitor beneath the cell at numerous locations. **Disadvantages:** Will require abundant measurements and extensive maintenance. Expensive. Point measurements - will need several wells to assess changes with depth. Requires special techniques to collect groundwater samples.	Installation of monitoring wells and sampling of spring and surface water.
	Sample springs/surface water.	**Advantages:** Can sample groundwater discharging at ground surface or springs or along gaining segments of streams. Does not require special sampling techniques. Inexpensive, repetitive sampling. Can sample high and low flows. **Disadvantages:** Sample locations are predefined. Cannot sample directly beneath the cell. May not sample at point of compliance. May not detect contaminant changes in aquifer prior to groundwater reaching point of compliance.	

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TABLE 5.4-7 Results of Modified Value Engineering: Groundwater Monitoring (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Structural access (galleries, portals).	**Advantages:** Can sample directly beneath the cell at multiple locations. Can be used to advance directional boreholes and to complete monitoring wells. **Disadvantages:** Very expensive. Interferes with natural system. May affect cell integrity.	
	Non-intrusive techniques.	**Advantages:** No effect on cell integrity; can conduct surveys from air or ground surface. Subsurface instrumentation not required; therefore, no effect on cell integrity and does not interfere with natural system. Longevity is not a problem. **Disadvantages:** Mainly used for characterization; subtle changes may be difficult to identify. Cannot quantify contamination or locate leaks in cells. May not be adequate as an early warning system.	

From Supporting Study 4B (Ref. 103).

TABLE 5.4-8 Observational Method: Groundwater Monitoring*

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Install monitoring wells.	Diffuse flow in the fractured Burlington-Keokuk aquifer system.	Fractured networks producing directional permeabilities controlling flow patterns.	High	Conduct single and double packer tests in open borehole sections during drilling.
		Open solution cavities in borehole sections.	Low on-site Medium off-site	Conduct cross-hole tracer tests to determine open and hydraulically communicative systems.
	Contaminant levels in leachate below current aquifer levels.	Contaminant levels in leachate higher than current aquifer levels.	Medium	Conduct numerical mass-transport simulations to determine whether monitoring wells will detect increases due to potential cell seepage.
Sample springs and surface water.	Contaminant levels in leachate below current springs/surface water levels.	Contaminant levels in leachate higher than current springs/ surface water levels.	Medium	Conduct numerical simulations of mass transport to determine whether springs/surface water can detect water quality due to feasible disposal cell performance.

* From Supporting Study 4B (Ref. 103)

TABLE 5.4-9 Data Needs: Groundwater Monitoring*

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Fractured networks produce directional permeabilities and control flow patterns.	Fracture spacing and attitudes.	Directional permeabilities, contaminant migration pathways, travel times through conduits.	Conduct single and double packer tests, cross-hole tracer tests, and short- and long-term pump tests.
Solution cavities in open borehole sections.	Dimensions of solution cavities.		
Contaminant levels in leachate greater than current aquifer and springs/surface water levels.	Distribution of contaminants in aquifer system. Expected contaminant levels in leachate.	Can monitoring wells and springs/surface water be located to detect increases in contamination due to seepage from cell.	Define contaminant distributions in aquifer system. Conduct bench-scale tests for leachate generation.

* From Supporting Study 4B (Ref. 103).

TABLE 5.4-10 Contaminants of Concern for the Weldon Spring Site

Radiological Parameters		
Uranium-238 Thorium-230 Thorium-232 Radium-226	Gross alpha Gross beta Gamma radiation	
Organics		
Nitrobenzene 2,4-Dinitrotoluene (2,4 DNT) 2,6-Dinitrotoluene (2,6 DNT)	2,4,6-Trinitrotoluene (TNT) Polychlorinated biphenyls (PCBs) DNT and TNT degradation products	
Inorganics/Metals/Asbestos		
Chromium Lithium Magnesium Nickel Vanadium Iron Lead	Zinc Molybdenum Arsenic Manganese Barium Beryllium	Sulfate Fluoride Nitrate

TABLE 5.5-1 Results of Modified Value Engineering: Long-Term Monitoring Maintenance

Evaluation Criteria	List Alternatives	Comments	Preferred Alternative
Provide long-term protection of human health and the environment through post-closure maintenance and monitoring of the Weldon Spring Site.	ARARs for:		Combination of ARARs, but leaning to those for RCRA cell. Preferred ARARs are:
Applicable requirement promulgated under Federal or State law that specifically addresses the long-term monitoring and maintenance at the WSS.	RCRA cell.	RCRA: • Most ARARs are acceptable for WSS. • The pose-closure monitoring plan will be prepared by the PMC. • The groundwater monitoring parameters will be proposed by the PMC and submitted to the EPA Regional Administrator for approval.	Preparation of a post-closure plan which identifies required activities after closure of the facility, and includes monitoring activities and frequencies; maintenance activities and frequencies; and the name, address, and phone number of the post-closure contact person. This will be an administrative activity for WSS but applied to the pose-closure requirements.
Relevant and appropriate equipment promulgated under Federal or State law that, while not applicable to a CERCLA site, addresses a situation sufficiently similar to those encountered at the WSS site and is well suited to the WSS.	UMTRA cell.	UMTRA: • Requirements are included in RCRA cell ARARs. • Groundwater monitoring requirement swill follow RCRA cell requirements.	Monitoring, reporting, and maintaining the WSS disposal facility for 30 yr after completion of closure.
Propose ARARs specific to WSS that will ensure long-term surveillance to accomplish the criteria stated above.	EPA/NRC mixed cell.	EPA/NRC Mixed Cell: • Not applicable.	Maintain the integrity and effectiveness of the final cover, including making repairs to the cap as necessary to correct the effects of settling, subsidence, erosion, or other events. This includes erosion protection from run-on and runoff.

TABLE 5.5-1 Results of Modified Value Engineering: Long-Term Monitoring and Maintenance (Continued)

	Sanitary landfill.	Sanitary Landfill: • Some ARARs correlate with those for RCRA cells. • A methane monitoring system will not be required for WSS. • Groundwater monitoring ARARs for WSS better correlated with those for RCRA cells.	Continue to operate the leachate collection and removal system until leachate is not longer detected or until determined by site personnel and the EPA Regional Administrator that this system is no longer necessary.
	TSCA-PCB cell.	TSCA/PCB Cell: • Some ARARs correlate with those for RCRA cells. • WSS not a chemical waste landfill. • TSCA/PCB post-closure ARARs apply only if PCB concentration of WSS wastes are greater than 50 ppm (current information indicates WSS wastes have less than 18 ppm.	Maintain and monitor the groundwater monitoring system and comply with all other applicable requirements of 40 CFR 264.90 *et seq.*
	Combination of ARARs from those listed above.		Protect and maintain surveyed benchmarks used to mark the location, dimensions, and contents of each cell. At WSS these benchmarks are those used to survey and dimension the storage facility.

TABLE 5.5-2 Elements of a Site-Specific Surveillance and Maintenance Plan

Introduction Site history Waste materials
Legal and regulatory requirements
Site location Regional map Site access map Legal description of the site Land ownership Site ownership
Site access Site access procedures Site security
Responsible parties
Final site conditions Climatic information Hydrogeology Hydrology Borehole logs and completion diagrams Water quality and uses Geochemistry of waste materials and stratigraphic units Nature and extent of contamination Aquifer-restoration requirements Vicinity map Map of final site conditions Remedial design

TABLE 5.5-2 Elements of a Site-Specific Surveillance and Maintenance Plan (Continued)

Final site conditions (Continued) As-builts Ground and aerial photographs Geographic information system Containment cell design and materials Off-site land use Sensitive ecosystems and historic and archaeological sites Soils Site vegetation Cover or containment cell performance Long-term cover or containment cell performance-assessment data Leachate collection system
Site inspections Types of inspections Routine inspection schedule Qualifications of inspectors Checklist for routine inspections Routine inspection procedures Follow-up inspections Inspection reports

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TABLE 5.5-2 Elements of a Site-Specific Surveillance and Maintenance Plan (Continued)

Environmental monitoring

- Groundwater monitoring
  - Need:
  - Groundwater regulations
  - Groundwater protection standard
  - Performance assessment
  - Closure performance standard
  - Existing monitoring network
  - Sampling plan
  - Data analysis and quality control
  - Schedule
  - Groundwater excursion
  - Restoration compliance
- Internal cell monitoring
- Leachate collection system
- Surface-water monitoring
- Soil-water monitoring
  - Soil-water parameters
  - Sampling design
  - Sampling methods
- Landform-modification monitoring
  - Erosion monitoring
- Vegetation monitoring
  - Vegetation parameters
  - Methods and instrumentation
  - Sampling design and data analysis
  - Plant invasion
- Burrow monitoring
- Aerial photography
- Radiation monitoring

TABLE 5.5-3 Degradation Mechanisms and Parameters to Consider for Vegetative Top Cover

Mechanism	Definition	Measurable Parameters
Water erosion	Movement of cover material from normally occurring site precipitation.	Precipitation characteristics. Soil loss or movement. Change in cover elevation.
Wind erosion	Movement of cover material from normally occurring site winds.	Wind characteristics. Soil loss or movement. Change in cover elevation.
Denudation	Vegetation stress leading to plant death without new plant growth.	Vegetation characteristics. Climatic conditions.
Human activities	Cover disturbance primarily by equipment operation and sample collection.	Soil loss or movement. Miscellaneous disturbance.
Biological intrusion	Animal or plant intrusion into the cover.	Animal or insect burrow depth. Plant root depth.
Freeze/thaw	Alternate freezing and thawing of near-surface soil moisture.	Soil temperature. Soil cracking or heaving. Water ponding or excessive mud.
Differential settlement	Mechanical settling from changing weight and compaction of host materials, waste, vault, and cover.	Change in cover elevation. Cover movement. Soil cracking. Water ponding.

TABLE 5.5-4 Degradation Mechanisms and Parameters to Consider for Sand/Gravel Layer

Mechanism	Definition	Measurable Parameters
Sedimentation	Mechanical or hydraulic transport of finer-grained particles in pore spaces.	Change in bulk density/porosity.
Differential settlement	Mechanical settling from changing weight and compaction of host materials, waste, vault, and cover.	Change in cover elevation. Horizontal continuity and thickness. Water ponding.

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TABLE 5.5-5 Degradation Mechanisms and Parameters to Consider for Clay Low- Permeability

Mechanism	Definition	Measurable Parameters
Biological intrusion	Animal or plant intrusion into the cover.	Animal or inspect burrow depth. Plant root depth.
Differential settlement	Mechanical settling from changing weight and compaction of host materials, waste, and cover.	Horizontal continuity and thickness. Change in cover elevation. Water ponding.
Shrink/swell/ redistribution	Movement of clay particles usually caused by changes in water content.	Horizontal continuity and thickness. Bulk density/porosity.

TABLE 5.5-6 Degradation Mechanisms and Parameters to Consider for Geotextiles and Geomembranes

Mechanism	Definition	Measurable Parameters
Chemical attack	Many waterborne chemicals react with thermoplastic materials, resulting in geosynthetic deterioration.	Geosynthetic fouling. Byproducts of polymer reactions. General degradation.
Photochemical attack	Oxidation of polymers by ultraviolet light.	Geosynthetic fouling. General degradation.
Ozone attack	Oxidation by ozone.	Geosynthetic fouling. General degradation.
Biological intrusion	Animal or plant intrusion into the geosynthetic.	Intrusion depth. Holes in geosynthetic.
Differential settlement	Mechanical settling from changing weight and compaction of host materials, waste, vault, and cover.	Holes, tears, and depression.
Thermal effects	Stretching and shrinking caused by temperature changes.	Holes, tears, and depression.

TABLE 6.1.2-1 Alternative Evaluation Summary

Material Type	Preferred Alternative	Potential Deviations	Data Collection
Raffinate Pit Sludge	Cutter-head dredge with slurry pump and pipeline.	Material won't dredge or pump.	Field test during waste treatment plant pilot test.
Raffinate Pit Clay Bottom and Dike	Backhoe or front-end loader and trucks.	Material won't support equipment; add gravel base.	None.*
In-place Soils	Combination of backhoes, self-loading scrapers, and front-end loaders.	Buried debris; more extensive contamination.	None.*
Building Foundations	Hoe ram front-end loaders, and trucks.	Deeper foundations; different material type.	Characterization: historical data review and physical observation.
Underground Utilities	Backhoe and trucks.	Deeper depths; unknown utilities present.	Characterization: historical data review and physical observation.
Stockpiled Material	Combination: backhoe, front-end loaders, and crane.	None.	None.*

* No additional data collection necessary to support CDR task.

TABLE 6.1.2-2 Observational Method - Raffinate Sludge

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
Dredge/slurry with pump	Dredge can remove material.	Dredge cannot remove material.	Low	Fatal – need alternate method.
	Material is pumpable.	Material not pumpable.	Low to medium	Fatal – need alternate method.
	Enough water available for emission control.	Not enough water.	Low	Implement other control methods; i.e., foam cover, plastic cover.
	Production rates can be met.	Unable to meet production requirements.	Low	Add equipment.

TABLE 6.1.2-3 Data Quality Objectives - Raffinate Sludge

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Dredge cannot remove material.	Fatal.	Can it effectively remove sludge.	Field test during treatment facility pilot testing.
Pump cannot transport material.	Fatal.	Can sludge be efficiently pumped.	Field test during treatment facility pilot testing.
Not enough water for emission control.	Implement other control methods.	None.	None.
Production rates are not met.	Add more or larger equipment.	What production rates must be met.	Obtain design criteria data from other tasks so that equipment will be selected that meets required production rates.

TABLE 6.1.2-4 Observational Method - Excavate/Remove Raffinate Pit Liner

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
No preparation.	Dry enough to work on.	Too sloppy for equipment operation.	High	Install gravel-base roadway.
Gravel-base roadways.	Stable base for equipment.	Still too sloppy - need to keep adding gravel until stable.	Low	Loss time adding additional gravel.
	Can control emission levels with water or foam.	Still too excessive.	Low	Cease operations until acceptable levels are again established.
	No debris in liner.	Debris in liner.	Low	Modify removal methods.
	Bottom two-thirds don't need treatment.	Does need treatment.	Low for all; medium for some	Little on excavation. Transport to treatment cell.
	3 ft need removal.	More or less needs removal.	Less - low More - medium	None; just excavate and haul away more or less as contamination levels warrant.
	Sludge has been removed.	Still some sludge left.	Low	Implement more dust control; modify excavation method.

TABLE 6.1.2-5 Data Quality Objectives - Excavate/Remove Raffinate Pit Liner

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Too sloppy for excavation equipment.	Need to keep adding gravel.	Too sloppy for practical removal operations.	None; need to remove water and sludge before question is answered. Could drill and sample but it might breach liner integrity; not worth the risk because gravel requirements can be easily incorporated.
Excessive emission levels.	None.	None.	None until removal is underway.
Debris in liner.	Modify removal methods slightly.	Is there debris?	None until excavation reveals debris.

TABLE 6.1.2-6 Observational Methods - In-Place Soils/Sediments

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Backhoe and truck.	Small areas. Deep excavation. Isolated areas. Confined areas. Irregular boundaries.	N/A	N/A	For areas meeting these expected conditions, use a backhoe.
Scrapers.	Large, shallow areas.	N/A	N/A	For areas meeting these expected conditions, use scrapers.
Combination of equipment types.	Single conditions within an area.	Combination of conditions within a given area	High	Use a combination of equipment and operating procedures.

TABLE 6.1.2-7 Data Quality Objectives - In-Place Soils/Sediments

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Combination of removal conditions within a small area.	None.	Will more than one type of equipment or operating procedure be required?	None.

TABLE 6.1.2-8 Observational Method - Rubblize Building Foundations

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Hoe ram everything.	Foundations will be readily reached from above ground.	Below ground removal required.	High	May be more affective to expose or remove with backhoe prior to rubblizing with hoe ram.
	Rebar will be cut using shears.	Shears can't cut it.	Low	Alternate method to be used (torch).
	Large monolithic concrete structures.	Unable to rubblize.	High	Handle as individual pieces and remove as unit.
	All foundations are concrete.	Steel pilings may be present.	Low	Cut off using torch below contamination or cell bottom lowest elevations.

TABLE 6.1.2-9 Data Quality Objectives - Rubblize Building Foundations

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Below ground removal required.	Foundations deeper than expected.	Will potential deviations affect design.	Historical search; physical observation. Work is not necessary to support the CDR task.
Monolithic structure is present.	Must be removed as a unit.		
Steel pilings are present.	Alternate removal method is necessary.		

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TABLE 6.1.2-10 Observational Method - Underground Utility Removal

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Backhoe.	Utilities not located at deep depths; backhoes can remove pipe when located above ground.	Pipes are at depths beyond easy reach of backhoe from above ground level.	High	Added equipment needed; use scraper to remove top layers of soil until an elevation amenable for backhoe use is reached.
	Backhoe can remove pipe.	Pipe cannot be removed by backhoe.	Low	Use alternate equipment and/or manual joint removal.
	No liquids in pipes.	Liquids are present.	Medium	Remove liquid prior to pipe removal.
	Contamination is localized in surrounding environs.	More extensive contamination.	High in isolated areas	More extensive excavation required.
	All utilities have been located prior to removal.	Unexpected utilities encountered.	High	More extensive removal than planned.

TABLE 6.1.2-11 Data Quality Objectives - Underground Utility Removal

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Utilities at greater depths than expected; some utilities not located prior to removal.	N/A	What are utility depths and where are they located.	Characterization; historical search and physical observation; not necessary to support CDR task.
Contamination in surrounding soils is extensive.	N/A	How extensive is contamination.	Soil sampling and testing during removal.

TABLE 6.1.2-12 Observational Methods - Stockpile Removal

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Front-end loader.	Loose material small enough to easily fit in FEL bucket.	Too large or heavy for FEL bucket.	High	Remove individual pieces using crane.
	Sufficient operating room.	Insufficient operating room.	Medium	Stockpile plan should provide adequate operating room; if not, use backhoe.

TABLE 6.1.2-13 Data Quality Objectives - Stockpile Removal

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Too large or heavy for FEL bucket.	None.	Identify items prior to removal.	None.
Insufficient operating room.	None.	Review stockpiles prior to removal.	None.

TABLE 6.1.2-14 Preliminary Material Removal Operating Statistics

Material Area	Production Rate (yd^3/hr)	Material Volume (yd^3)	Total Duration (hours)	Duration (months)
North Dump	70	7,839	112	1.0
Frog Pond	70	7,373	106	1.0
Foundations	60	40,600	812	7.0
Underground piping	126^{lf}/hr 90^{lf}/hr	$64,246^{lf}$ $64,246^{lf}$	510 714	6.0
CP Area Soils • at pipes • at surface • below surface	 56 80 40	 20,000 26,400 41,800	 357 330 1,045	 9.0
Raffinate Pit Area	70	16,934	242	2.0
Ash Pond Stock	55	207,429	3,771	30.0
Ash Pond	70	8,462	121	1.0
South Dump	70	17,160	245	2.0
MSA materials	55	71,550	1,300	10.0
TSA materials excavate soils	55	70,330	1,279	10.0
Vicinity Properties • Army Property 1 • Busch Property 4; Army Property 2 • Busch Properties 3 and 5 • Army Property 3 • Army Properties 5 and 6 • Busch Lakes 34 • Busch Lakes 35 • Busch Lakes 36	 32 20 5 5 46 85 85 85	 1,160 630 50 60 1,700 6,000 5,000 7,000	 36 32 10 12 37 94 59 62	 0.5 0.5 0.1 0.1 0.5 1.0 1.0 1.0
Dewater Pit 1	35 gpm	821,579	392	1.0
Dewater Pit 2	50 gpm	817,495	273	1.0
Dewater Pit 3	35 gpm	4,624,304	2,202	3.0
Dewater Pit 4	50 gpm	34,232,333	11,411	16.0
Final Dewater Pit 1	35 gpm	678,421	323	1.0
Final Dewater Pit 2	50 gpm	682,505	228	1.0
Final Dewater Pit 3	35 gpm	4,975,696	2,370	4.0
Final Dewater Pit 4	50 gpm	8,767,667	2,923	4.0

TABLE 6.1.2-14 Preliminary Material Removal Operating Statistics (Continued)

Material Area	Production Rate (yd^3/hr)	Material Volume (yd^3)	Total Duration (hours)	Duration (months)
Pit 1 Top	70	4,181	60	1.0
Pit 2 Top	70	4,201	60	1.0
Pit 3 Top	70	18,874	270	3.0
Pit 4 Top	70	29,927	428	4.0
Pit 1 Bottom	70	4,692	67	1.0
Pit 2 Bottom	70	4,712	67	1.0
Pit 3 Bottom	70	25,970	371	3.0
Pit 4 Bottom	70	44,747	639	6.0
TSA Soils	55	52,000	946	8.0
CSS Product	50	222,500	4,450	16.0
VIT Product 90 yd^3/day	30	126,000	4,200	33

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TABLE 6.1.3-1 Preliminary Material Transportation Operating Statistics

Material Area	Schedule Duration	Haul Route		Haul Cycle (min)	Trips/ Hr	Total Route Length (ft)
		To	From			
North Dump	1.0	North Dump	Ash Pond	11.3	6.2	4,357
Frog Pond	1.0	Frog Pond	Ash Pond	14.8	4.7	7,452
Foundation	7.0	CP Area	Ash Pond	13.4	3.7	6,146
Underground Piping	6.0					
CP Area Soils • at pipes • at surface • below surface	9.0	CP Area	Ash Pond	13.4	4.2 6.0 3.0	6,146
Raffinate Pit Area	2.0	RP Area	Ash	12.9	5.4	5,733
Ash Pond Stack	30.0	Ash Pond/spoil area	DF	14.6	3.9	7,042
Ash Pond	1.0	Ash Pond	DF	14.5	4.8	7,042
South Dump	2.0	South Dump	DF	14.5	4.8	7,042
MSA Materials	10.0	MSA	DF	14.6	3.8	7,192
TSA Materials Excavate Soils	10.0	TSA	DF	12.3	4.5	6,242

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TABLE 6.1.3-1 Preliminary Material Transportation Operating Statistics (Continued)

Material Area	Schedule Duration	Haul Route		Haul Cycle (min)	Trips/ Hr	Total Route Length (ft)
		To	From			
Vicinity Properties		VP	DF	36.7		35,300
• Army Property 1	0.5				0.9	
• Busch Property 4; Army Property 2	0.5				1.8	
• Busch Properties 3 and 5	0.1				0.1	
• Army Property 3	0.1				0.1	
• Army Properties 5 and 6	0.5				1.3	
• Busch Lakes 34	1.0				2.3	
• Busch Lakes 35	1.0				2.3	
• Busch Lakes 36	1.0				2.3	
Dewater Pit 1	1.0	Pits	SWTP	-	-	-
Dewater Pit 2	1.0	Pits	SWTP	-	-	-
Dewater Pit 3	3.0	Pits	SWTP	-	-	-
Dewater Pit 4	16.0	Pits	SWTP	-	-	-
Final Dewater Pit 1	1.0	Pits	SWTP	-	-	-
Final Dewater Pit 2	1.0	Pits	SWTP	-	-	-
Final Dewater Pit 3	4.0	Pits	SWTP	-	-	-
Final Dewater Pit 4	4.0	Pits	SWTP	-	-	-
Pit 1 Top	1.0	Pits	TF	8.2	8.5	1,581
Pit 2 Top	1.0	Pits	TF	8.2	8.5	1,581

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TABLE 6.1.3-1 Preliminary Material Transportation Operating Statistics (Continued)

Material Area	Schedule Duration	Haul Route		Haul Cycle (min)	Trips/ Hr	Total Route Length (ft)
		To	From			
Pit 3 Top	3.0	Pits	TF	12.7	5.5	5,744
Pit 4 Top	4.0	Pits	TF	12.8	5.6	5,606
Pit 1 Bottom	1.0	Pits	DF	11.9	5.9	4,883
Pit 2 Bottom	1.0	Pits	DF	11.0	6.4	4,078
Pit 3 Bottom	3.0	Pits	DF	13.7	5.1	6,454
Pit 4 Bottom	5.0	Pits	DF	14.8	4.7	7,342
TSA Soils	8.0	TSA	TF	9.9	5.6	3,088
CSS Product	18.0	TF	DF	11.7	4.3	4,466
VIT Product 90 yd^3/day	33	TF	DF	11.7	2.6	4,466

TABLE 6.2.3-1 Summary of Construction Operations

Construction Sequential Order	Construction Operation	Equipment
1	Stripping of topsoil, clearing and grubbing of vegetation and debris.	Loaders and dozers.
2	Excavation of clean soils to required elevation.	Dozers, scrapers and backhoes.
3	Backfilling and compaction of clean soils to final foundation elevation.	Loaders, scrapers, tamper, rectangular base-plate vibrator, sheepsfoot rollers and graders.

Source: (Ref. 60)

TABLE 6.2.5-1 Waste Types and Volumes

No.	Waste Type	In Situ Vol. (yd³)	CSS Alternative			Vitrification Alternative		
			CSS Waste Form	Other Waste Forms	Total Waste	Vitrified Waste Form	Non-Vit Waste Forms	Total Waste
1	Sludge	227,700	300,600		300,600	34,844		34,844
2	Soils/sediments	440,800	140,210	334,580	474,790	84,976	334,580	419,556
3	Metals	62,385						
3a	Shred			13,101	13,101		13,101	13,101
3b	Reduce			8,734	8,734		8,734	8,734
3c	Intact			40,550	40,550		40,550	40,550
4	Masonry Block DEBRIS	7,300		7,300	7,300		7,300	7,300
5	Rock/concrete DEBRIS	104,961		104,961	104,961		104,961	104,961
6	Asbestos	10,089		10,089	10,089		10,089	10,089
7	PPE	7,813		781	781		781	781
8	Miscellaneous DEBRIS	281		281	281		281	281
9	Containerized materials							
9a	Cont. Chemicals (RCRA)*	139		0	0		0	0
9b	Other "434 materials"	170		170	170		170	170
10	Soil/gravel mixtures	90,800		90,800	90,800		90,800	90,800
11	Wood	32,210		6,442	6,442		6,442	6,442
	Totals	984,648	440,810	617,789	1,058,599	119,820	617,789	737,609

* These RCRA materials will be removed from the site and disposed of elsewhere.
(Ref. 4)

TABLE 6.2.5-2 Results of Modified Value Engineering- Waste Placement

Evaluation Criteria (Weight from MVE)	List Alternatives (Final Rating)		Advantages/Disadvantages	Preferred Alternative
1. Method of Grout Placement for Entombing Metal Waste				
Worker Exposure (12.0): Exposure to environmental or occupational hazards.	Boom pump trucks. Concrete trucks haul CSS grout to cell and pour into pump hopper. Pump operators remain most times on top of trucks operating booms hydraulically. Workers do not hold onto hose, but may aim hose with ropes from a distance. Metal placed in about 2-ft lifts. If necessary, vibration may be provided by shaker-head on backhoe or tapping with excavator. Assuming CSS grout is produced at about 135 cu yd/hr, two trucks would be required.	1	**Advantages:** Good protection of worker; minimum exposure to CSS and potentially sharp metal wastes--no one needs to get close to the placement operation. Grout can be placed around any shape of metal, or pumped into pipes. All voids should be reachable by this method. With minimal supplemental vibration, from a shaker-head, tamping with excavator, or some other method, voids should be filled. The operation will use conventional construction equipment. There be no hazards from equipment driving over irregular surfaces during placement. Dozer and loader tracks and buckets will not be dirtied. Cleanup operations each day will be similar to an uncontaminated concrete pumping operation. **Disadvantages:** No serious disadvantages. Pump could become clogged, but by limiting the length of the rubber hose on the end of the boom, problems should be a minimal. Filling of all voids could be a impractical.	Use two boom pump trucks.

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TABLE 6.2.5-2 Results of Modified Value Engineering - Waste Placement (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	(Final Rating)	Advantages/Disadvantages	Preferred Alternative
Flexibility with variety of metal waste forms (1.0): Different shapes can be handled without major change in operation. Adequacy of void filling (6.0): Requires that excessive settlement will not ensue when metal corrodes. Ease of the operation (1.0): Minimum of special equipment or training. Only small number of variations in operation necessary.	Spread grout with loader or excavator. Dump grout on ground adjacent to metal, and loader or excavator moves it onto waste.	2	**Advantages:** The loader required may already be on site for other operations. **Disadvantages:** Operating loader over loose metal may be dangerous. Using excavator may work, but would be slow and cumbersome. Would need to place grout on ground and then pick it up, which would create additional patches of messy ground during each day's operation. Grout may be too sloppy (high slump) for effective loading/unloading handling.	
2. Method of Filling of Voids in Concrete Rubble				
Worker exposure (13.0).	Fill voids with CSS grout placed by pump truck.	1	**Advantages:** Best cell integrity, most voids expected to be filled with average effort. **Disadvantages:** Requires grout, but apparently plenty can be made.	CSS grout preferred. Soil-like CSS also good option; more voids will remain unfilled, but the integrity of the cell will not be compromised. Soil will work well enough for the VIT option; additional voids will remain, and settlement may be somewhat higher, but the cover can be designed to accommodate this.
	Fill voids with soil-like CSS. Place with loader and track-walk to work into concrete rubble voids.	3	**Advantages:** Good cell integrity. **Disadvantages:** Doesn't fill voids as well as grout. Requires extra effort to compact CSS on or around concrete rubble.	

TABLE 6.2.5-2 Results of Modified Value Engineering - Waste Placement (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Rating]	Advantages/Disadvantages	Preferred Alternative
Integrity of cell (13.0). Volume reduction (1.0): Minimize voids to extent possible. Ease of operation (1.0) Accommodation of available waste volumes (5.0): i.e., be able to handle whatever waste form is ready for placement in manner most convenient for other site operations.	Fill voids with soil. Place with loader and track-walk to work into concrete rubble voids.	2	**Advantages:** Doesn't require grout pump to fill concrete rubble. **Disadvantages:** Doesn't fill voids as well as grout; cell not quite as good integrity as either CSS option. Requires extra effort to compact CSS on or around concrete rubble. CSS grout preferred. Soil-like CSS also good option; more voids will remain unfilled but the integrity of the cell will not be compromised. Soil will work well enough for the VIT option; additional voids will remain, and settlement may be somewhat higher, but the cover can be designed to accommodate this.	

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TABLE 6.2.5-2 Results of Modified Value Engineering - Waste Placement (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives [Final Rating]		Advantages/Disadvantages	Preferred Alternative
3. Disposal of Friable Asbestos				
Worker exposure (9.0): Extra handling of asbestos would expose workers to asbestos hazard, as they would need appropriate PPE. Integrity of cell (9.0): Will asbestos-related settlement cause distress to the cell. Ease of operation (2.0): Use standard construction procedures when possible, and as few special precautions as possible. Waste volume (0.0): How to place asbestos with as few voids as possible.	Place Sea-Land containers in disposal cell. Asbestos bags are currently being moved to short-term storage in Sea-Land containers. These containers full of asbestos could be placed in the cell and covered.	2	**Advantages:** Easiest operation for placement. Minimal worker exposure because bags are not rehandled. **Disadvantages:** Cell integrity likely to be compromised in the long term as containers corrode and leave low density, compressible bagged asbestos. Compaction around containers will take extra effort.	Remove asbestos from Sea-Land containers and place in trenches.
	Remove bagged friable asbestos from Sea-Land containers and place bagged asbestos in cell in trenches or holes.	[1]	**Advantages:** Best protection of long-term cell integrity. **Disadvantages:** Requires rehandling of bagged asbestos. Requires minor effort to create trenches or holes.	

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TABLE 6.2.5-2 Results of Modified Value Engineering - Waste Placement (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Rating]	Advantages/Disadvantages	Preferred Alternative
4. Disposal of Large-Diameter Pipe				
Worker exposure (13.0): Doesn't require workers to get too close to CSS operation (to avoid splattering) or to OSHA risks. Integrity of cell (13.0). Volume reduction (1.0): Minimize voids. Ease of operation (1.0): Doesn't require significant special operations. Speed of operation (5.0): Accommodation of available waste volumes, without getting in way of other operations.	Split any pipe over certain diameter using shears or welding torch.	3	**Advantages:** Facilitates void filling for volume reduction and cell integrity. **Disadvantages:** Tedious operation for some pipe. Prolong worker exposure.	From waste placement perspective, any option will work. Filling large diameter pipe appears best, particularly with reinforced concrete pipe which may be hard to split or crush. Crushing may be best for thin-wall pipe and breaking may be best for clay or cast iron pipe. Splitting will work but may be harder to do.
	Fill pipe over certain diameter. Suggested method is to grade subgrade with 25±% slope, and lay pipe on this slope. Place grout hose in uphill open end of pipe and pump until roughly full.	1	**Advantages:** Relatively effective void filling for volume reduction and cell integrity. Less tedious than splitting pipe. Filling operation uses boom truck without substantially changing operation. **Disadvantages:** Requires construction of sloping subgrade to set pipe on (minor disadvantage).	
	Crush/break pipe over certain diameter, using hoe ram or crusher jaws.	2	**Advantages:** Reduce or eliminate voids for cell volume reduction. **Disadvantages:** May still leaves voids. More tedious work than filling pipe. From waste placement perspective, any option will work. Filling large diameter pipe appears best, particularly with reinforced concrete pipe that may be hard to split or crush. Crushing may be best for thin-wall pipe and breaking may be best for clay or cast iron pipe. Splitting will work ,but may be harder to do.	

Table 6.2.5-3 Summary of Waste Placement Methods

Waste Type	Form During Placement	Delivery Method	Placement Method	Comments
Raffinate Sludge	Grout-like CSS.	Haul on site with transit mixers or concrete dumps.	Pump with boom-truck concrete pump.	--
	Soil-like CSS.	End-dump trucks.	If too wet to work, allow to set in heaps overnight, then place and compact with conventional earthwork equipment. If wet but workable, consider track-walking into place; if dry, place and compact with conventional earthwork equipment.	Sheepsfoot compaction (or possibly track dozer/loader).
	VIT.	End-dump trucks.	Place and compact with conventional earthwork equipment.	Vibratory compaction.
Soils/Sediments	Soil/sediment.	End-dump trucks.	Place and compact with conventional earthwork equipment.	Sheepsfoot compaction.
Metal	Varies from iron filings to long beams, and includes one small locomotive.	End-dump trucks or flatbeds.	Place with excavator with thumb or grapple in 1 ft to 3 ft lifts, then entomb with CSS.	Crane may be required for the heaviest pieces of metal.
			For VIT, recommend entombing the metal waste in clean grout from off site. If this is not permissible, the placement should be in thinner lifts, generally ≤ 18 in., covered with vitrified product or contaminated soil, and compacted.	
Large-Diameter Pipe (> 12 in.)	Steel.	End-dump trucks or flatbeds.	Like metal.	Smashed flat before delivery.
	Reinforced concrete.		Fill with CSS grout.	Delivered in whole sections.
	Cast iron or ceramic.		Like metal.	Broken before delivery.

Table 6.2.5–3: Summary of Waste Placement Methods (Continued)

Waste Type	Form During Placement	Delivery Method	Placement Method	Comments
Masonry Block	Moderately crushed, to 3 ft maximum dimension.	End-dump trucks.	Place and compact with conventional earthwork equipment.	Track-walk or vibratory compaction.
Rock/Concrete Debris	3 ft maximum dimension.	End-dump trucks, possibly without tail-gate.	Place and compact with conventional earthwork equipment.	Track-walk or vibratory compaction.
Asbestos	Friable, bagged.	Deliver in Sea-Land containers with semi-trailer rig.	Bury in trenches, compact overburden.	Track-walk first overburden lift to avoid puncturing bags; then use sheepsfoot compaction.
	Nonfriable, primarily transite, roofing, or siding.	End-dump trucks.	Place and compact with conventional earthwork equipment.	Sheepsfoot compaction.
PPE	Bundled, compressed.	Any truck or loader.	Bury in trenches, compact overburden.	Sheepsfoot compaction.
Miscellaneous	Variable (office furniture.	End-dump trucks or dumpster hauler.	Place and compact with conventional earthwork equipment.	Track-walk or vibratory compaction.
Containerized Chemicals (non-RCRA)	Neutralized, treated.	Like CSS.	Like CSS.	–
Soil/Gravel Mixtures	Soil/gravel.	End-dump trucks.	Place and compact with conventional earthwork equipment.	Track-walk or vibratory compaction for granular material; Sheepsfoot compaction for cohesive.
Wood	Composted.	End-dump trucks.	Place and compact with conventional earthwork equipment.	Sheepsfoot compaction.

TABLE 6.2.5-4 Observational Method - Waste Placement

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
1. Method of Filling Voids in Concrete Rubble				
Fill voids in concrete rubble with CSS grout.	There will be enough CSS grout to entomb all metal and concrete.	There may not be enough CSS grout without adding water to the mix (may be regulatory concerns with increasing waste volume).	Low	Could add water to mix to produce more grout. Not sure if this would be allowed. Could fill concrete voids with soil or soil-like CSS. This is acceptable, though not first choice.
	CSS grout may be placed in cell directly from the treatment plant.	It may be ruled that "free water" in fresh CSS product is not allowed to be placed in cell.	Low	Would need to allow time for initial set or hydration prior to placement in cell. Could not entomb metal or concrete.
2. Disposal of Friable Asbestos				
Remove friable asbestos from Sea-Land containers before placing in cell.	Asbestos will be in bags.	Many of the bags will have burst or will have disintegrated by the time of placement in the cell.	High	Seek guidance from experienced asbestos handlers. May need to mist the area, or rebag the asbestos.

TABLE 6.2.5-5 Data Quality Objectives - Waste Placement

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
1. Method of Filling in Voids in Concrete Rubble			
There may not be enough CSS grout without adding water to the mix (may be regulatory concerns with increasing waste volume).	Yes	Evaluate the anticipated volume and potential volume of grout to be produced.	None.
It may be ruled that "free water" in fresh CSS product is not allowed to be placed in cell.	Yes	Will fresh CSS product be allowed to be placed in cell?	Get regulatory ruling.
2. Disposal of Friable Asbestos			
Many of the bags may have burst or disintegrated prior to placement in the cell.	Yes	Discuss with experienced asbestos handlers.	Condition of bags, i.e., likelihood of bursting or disintegrating.

TABLE 6.2.5-6 Results of Modified Value Engineering - Number of Shifts

Evaluation Criteria (Weight from MVE)	List Alternatives	[Final Rating]	Advantages/Disadvantages	Preferred Alternative
1. Number of CSS-Production Shifts Per Day				
Worker exposure (11.0).	Single shift per day.	3	**Advantages.** Single crew, all daylight operation. **Disadvantages.** Rate of CSS production limits rate of cell construction. CSS may lag behind metal and/or concrete rubble placement.	24-hr is preferred; double shift is second choice.
	Double shift per day.	2	**Advantages.** Less cleanup time per shift (one shutdown per two shifts). CSS will probably be able to keep up with metal and concrete rubble placement. Will speed up overall cell construction considerably, with significant cost savings possible. **Disadvantages.** Need second crew. Need lights. Possible approval problems.	

TABLE 6.2.5–6 Results of Modified Value Engineering - Number of Shifts (Continued)

Evaluation Criteria (Weight from MVE)	List Alternatives	(Final Rating)	Advantages/Disadvantages	Preferred Alternative
Integrity of cell (10.0). Duration of waste placement (3.0). Accommodation of available waste schedule (4.0). Ease of construction (0.0).	24-hr CSS production (Note: graveyard shift may operate at less than full capacity.)	1	**Advantages.** Less cleanup time per shift (one shutdown per 15 shifts on Friday night). Could easily keep up with metal and concrete rubble placement. Will speed up overall cell construction considerably, with significant cost savings possible. CSS plant could probably be operated at from one third to full capacity graveyard or swing to match placement needs. **Disadvantages.** Need third crew. Need lights. Possible approval problems. Larger layoff in winter. Possibly more frequent breakdowns, because there are no regular daily downtimes for daily maintenance.	

TABLE 6.2.5–7 Observational Method - Number of Shifts

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Effect on Design
1. Number of CSS-Production Shifts Per Day				
Place CSS in two or three shifts.	Permissible to work at night.	ES&H, public, or regulatory agencies my not permit night work.	Unknown	Place CSS in as many shifts as permissible without getting too far ahead of other operations. May be best to use two rather than three shifts, even if three are permitted.

TABLE 6.2.5-8 Data Quality Objectives - Number of Shifts

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
1. Number of CSS-Production Shifts Per Day			
ES&H, public, or regulatory agencies may not permit night work.	Yes	Will it be permissible to operate at night?	Public opinion, ES&H opinion, and regulatory opinions regarding night work.

TABLE 6.3.2-1 Results of Modified Value Engineering: Material Preparation - Material Separator (Dry Material)

Evaluation Criteria	List Alternatives	Advantages/Disadvantage	Preferred Alternative
Mechanical reliability. Ease of operation. Cost (high, moderate, low). Maintenance. Handle wide range of particle size. Adaptable for dust control.	Vibrating screen.	**Advantages:** Mechanically reliable. Easy of operation. High volume capacity. Will handle wide range particle size. Adaptable for dust control. **Disadvantages:** Will not break large lumps.	Vibrating screen.
	Vibrating grizzly.	**Advantages:** Mechanically reliable. Easy of operation. High volume capacity. Adaptable for dust control. Low maintenance. Can handle and break large lumps. Low cost. **Disadvantages:** Does not separate wide range of particles.	Vibrating grizzly.
	Rotating trommel.	**Advantages:** Mechanically reliable. High volume capacity. **Disadvantages:** Not adaptable for dust control. High cost. High maintenance.	Both equipment running in series in order vibrating grizzly and vibrating screen.

TABLE 6.3.2-2 Observational Method: Material Preparation - Material Separator (Dry Material)

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Vibrating grizzly and vibrating screen in series.	The grizzly is providing basic separation of oversized material and breaking the lumps.	Dust suppression will moisturize material too much.	Low	Decrease dust suppression and provide local dust exhaust and filtration.
	Screen is separating oversized material from -2 in. product.	Unexpected amount of oversized material will decrease the capacity of -2 in. product.	Moderate	None. Note: Operator in TSA shall avoid this situation.

TABLE 6.3.2-3 Data Quality Objectives: Material Preparation - Material Separator (Dry Material)

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
The dust suppression will moisturize material too much. Unexpected amount of oversized material will decrease the capacity of -2 in. product	Decrease the moisturizing element. Relocation the sprayers to more effecting location. Control moisture of soils before processing. Control the grizzly feed.	How will the delivered moisture content of soils be controlled? How unexpected amount of oversized material can be avoided? Is the radon evolution possible in soil processing?	Sampling of soils. The operator shall provide a selective loading to average material content. Testing required.

TABLE 6.3.2-4 Results of Modified Value Engineering: Material Preparation - Oversized Material Washing

Evaluation Criteria	List Alternatives	Advantages/Disadvantage	Preferred Alternative
Mechanical reliability. Easy of operation. Cost (high, moderate, low). Maintenance. Handle wide range of particle size.	Washing rotating trommel.	**Advantages:** Mechanically reliable. Easy of operation. Low water consumption. Moderate maintenance. Handle of wide range of particle size. **Disadvantages:** High cost.	Rotating trommel.
	Wet vibrating screen.	**Advantages:** Mechanically reliable. Easy of operation. Moderate cost. High maintenance. **Disadvantages:** High water consumption. Doesn't handle the wide range of particles.	

TABLE 6.3.2-5 **Observational Methods: Material Preparation - Oversized Material Washing**

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Rotating trommel.	The material feed is consistent.	Water shut down.	Moderate.	Monitoring and control system needed.
	The material/water ratio is balanced.	Screen plug.	Low.	Provide the accessibility for cleanup.
	Screen operates without plugging.	Radon emission detected.	Moderate.	Radon control shall be provided.

TABLE 6.3.2-6 Data Quality Objectives: Material Preparation - Oversized Material Washing

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Water shut down.	Provide standby pump for water supply.	Is the secondary water supply necessary?	Determine the water recyclability.
Screen plug.	Provide design for feed and water control ratio.	How to monitor and control this ratio?	Sample both substances and monitor the optimum ratio.
Radon emission detected.	Enclose and seal the system for radon containment.	Will washing and agitation cause the radon emissions?	Collect sample.

TABLE 6.3.2-7 Results of Modified Value Engineering: Material Preparation - Material Conveying - Horizontal

Evaluation Criteria	List Alternatives	Advantages/Disadvantage	Preferred Alternative
Mechanical reliability. Easy of operation. Cost (high, moderate, low). Maintenance. Adaptable for dust control. Handle wide range of particle sizes. Handle high capacities. Can provide long distance material handling.	Enclosed belt conveyor.	**Advantages:** Mechanically reliable. Easy of operation. Handle wide range of particle sizes. Handle high capacities. Adaptable for dust control. Provide long distance of material handling. Moderate cost. **Disadvantages:** High maintenance. Difficulty to prevent spillage of material.	Enclosed belt conveyor (for horizontal or inclined conveying).
	Screw conveyor.	**Advantages:** Mechanically reliable. Easy of operation. Enclosed and sealed system. Handle high capacities. **Disadvantages:** Cannot handle wide range of particle sizes. Length of the conveyor is limited. The elevation of material is limited.	
	Screw lift.	**Advantages:** Mechanically reliable. Easy of operation. Enclosed and sealed system. **Disadvantages:** Low capacity. Can't handle wide range of particle size. Conveying height and length is limited. High cost.	

TABLE 6.3.2-7 Results of Modified Value Engineering: Material Preparation - Material Conveying - Horizontal (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantage	Preferred Alternative
	Bucket elevator.	**Advantages:** Mechanically reliable. Handle high capacities. Handle wide range of particle sizes. Enclosed and sealed system. Elevation of material is not restricted. **Disadvantages:** Moderate maintenance. More prone to spillage.	Bucket elevator.

TABLE 6.3.2-8 Observational Method: Material Preparation - Material Conveying - Horizontal

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Enclosed belt conveyor for horizontal conveying.	The conveyor capacity is stable. Belt strength is constant.	Excessive spillage of material from belt return. Not acceptable dust propagation.	Moderate.	Incorporate alternative scraper design. Special design consideration for enclosure and seals.
Bucket elevator for vertical conveying.	Constant capacity on feed and discharge.	Dust propagation on feed and discharge.	Low	Special design for enclosure and seals. Possible dust collection from top of the equipment.

TABLE 6.3.2-9 Data Quality Objectives: Material Preparation - Material Conveying - Horizontal

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Excessive spillage of material from belt return.	Proper belt cleaning system adjustment.	How the belt cleaning can be improved?	Material cohesiveness have to be tested.
Not acceptable dust propagation.	None (contact vendor).	How the conventional equipment can be adapted for hazardous waste?	None.
Dust propagation from bucket elevators feed and discharge.	None (contact vendor).		

TABLE 6.3.2-10 Results of Modified Value Engineering: Material Preparation - Pumps

Evaluation Criteria	List Alternatives	Advantages/Disadvantage	Preferred Alternative
Mechanical reliability. Maintenance. Cost (high, moderate, low). Slurry (solids) handling ability. High head. Handle high capacities.	High speed centrifugal pump.	**Advantages:** Mechanical reliability. Low maintenance. Low cost. Ability to handle heavy slurry. High mixing ability. High head. High capacity. **Disadvantages:** Higher abrasion than low speed pumps.	High speed centrifugal pumps (selected primary for high mixing ability.
	Progressive cavity.	**Advantages:** Can handle high viscosity fluids. High head. Mechanical reliability. **Disadvantages:** High cost. Can handle only moderate capacity. High maintenance.	
	Gear pump.	**Advantages:** Mechanical reliability. High head. Low maintenance. Can handle high capacity. **Disadvantages:** Inability to handle solids. High cost.	

TABLE 6.3.2-11 Observational Method: Material Preparation - Pumps

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
High speed centrifugal pump.	The pump is operating under constant pressure and capacity.	The shaft seal leaks.	Low.	Use different material for the shaft seal.

TABLE 6.3.2-12 Data Quality Objectives: Material Preparation - Pumps

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
The shaft seal leaks.	None.	How abrasive will be raffinate on pumps and piping systems? Chemical consistency of raffinate required special development of shaft seal?	

TABLE 6.3.2-13 Results of Modified Value Engineering: Radon Adsorption

Evaluation Criteria	List Alternatives	Advantages/Disadvantage	Preferred Alternative
Adsorption efficiency. Adsorption capacity. Cost. State of technology.	Carbon adsorber.	**Advantages:** High adsorption efficiency. Low carbon cost. High adsorption capacity. State of art technology. **Disadvantages:** Carbon is not reusable (have to be disposed into waste cell).	Carbon adsorber.
	Molecular sieve.	**Advantages:** No disposable adsorbent. **Disadvantages:** Not proven technology. High pressure operation. High cost.	

TABLE 6.3.2-14 Observational Method: Radon Adsorption

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Carbon adsorber.	The adsorber is working with full efficiency.	Low adsorption.	Low.	Increase adsorption area by adding more units or decrease the flow below superficial velocity or reduce the moisture in the gas by adding a dryer.

TABLE 6.3.2-15 Data Quality Objectives: Radon Adsorption

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Low adsorption.	None.	How will the radon adsorb in high pressure condition?	Testing required.

TABLE 6.3.2-16 Results of Modified Value Engineering: Plant Feed System

Evaluation Criteria	List Alternatives	Advantages/Disadvantage	Preferred Alternative
Mechanical reliability. Ease of operation. Cost. Maintenance.	Mechanical feeder (screw conveyor).	**Advantages:** Mechanically reliable. Enclosed and sealed. Variable speed available. Easy of operation. High capacity. **Disadvantages:** Particle size limitations. Limited conveying length.	Hydraulically driven mechanical feeder for soil material.
Large capacity. Handle wide range of particle size. Adaptable for dust control. Variable speed availability.	Pneumatic system.	**Advantages:** Mechanically reliable. Low cost. Large capacity. Sealed system. **Disadvantages:** High maintenance. Limited particle size.	Pneumatic feeder for cement and fly ash.

TABLE 6.3.2-17 Observational Method: Plant Feed System

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Hydraulically driven. Mechanical feeder for soil material in combination with pneumatic.	Constant soil feed at selected capacity.	The capacity decrease for bridging in the feed hopper.	Low.	Live bottom bin discharge needed.
Feeder for cement and fly ash.	Constant cement and fly ash feed at selected capacity.	The capacity decrease.	Low.	Vent filter capacity is low.

TABLE 6.3.2-18 Data Quality Objectives: Plant Feed System

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
The capacity decrease for bridging in the feed hopper.	See previous table.	How the moisture content of soils can be monitored in material preparation?	
The capacity of pneumatic feed system decrease.	See previous table.	None.	None.

TABLE 6.3.2-19 Results of Modified Value Engineering: Mixing System

Evaluation Criteria	List Alternatives	Advantages/Disadvantage	Preferred Alternative
Mechanical reliability. Ease of operation. Cost (high, moderate, low). Maintenance. Variable speed option.	High shear mixer.	**Advantages:** Mechanically reliable. Easy to operate. Moderate cost. Easy to maintain. Variable speed option. **Disadvantages:** No continuous operation possible.	High shear mixer for primary mixing.
	Pug mill.	**Advantages:** Mechanically reliable. Easy to operate. Easy to maintain. Variable speed option. **Disadvantages:** Limited mixing time (fixed length).	Pug mill for secondary mixing.
	Ribbon mixer.	**Advantages:** Mechanically reliable. Moderate cost. Easy to operate. Variable speed option. **Disadvantages:** Not constructed for soil-like type materials.	
	Homogenizator.	**Advantages:** Mechanically reliable. Easy to maintain. Easy to operate. **Disadvantages:** Very short residence time - not acceptable as mixer.	

TABLE 6.3.2-20 Observational Method: Mixing System

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
High shear mixer for primary mixing in series with pug mill for secondary mixing.	The primary mixing is in the time tolerance for proper mix.	The product is too dry.	Moderate.	Provide water supply into primary mixer.
		The product is too moist.	Low.	Non (addition of fly ash needed).

TABLE 6.3.2-21 Data Quality Objectives: Mixing System

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
The product is too dry. The product is too moist.		How to dewater the raffinate (source of the water for the mix) to hold the water content constant?	Study raffinate dewatering process.

TABLE 6.3.3-1 Results of Modified Value Engineering for Melter Technology

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Minimization of residual waste. State of development of technology. Impact of system failure. Additional treatment requirements. Flexibility in accepting feed with variable chemistry. Requirements for physical pretreatment of waste. Mechanical availability. Maintainability. Relative product quality. Ease of operation. Energy conservation. Ability to accept other wastes. Cost.	Fossil fuel-heated ceramic melters.	**Advantages:** Minimization of residual waste. State of development of technology. Impact of system failure. No additional treatment requirements. Flexibility in accepting feed with variable chemistry. Maintainability. Relative product quality. Ease of operation. Energy conservation. Ability to accept other wastes. Very low cost relative to PAT and JHCM. **Disadvantages:** No requirements for physical pretreatment of waste. Larger off-gas flow perceived as more difficult to treat relative to PAT and JHCM.	Fossil fuel-heated ceramic melters (recommend PATs as backup to FFHCM, but need more information).

TABLE 6.3.3-1 Results of Modified Value Engineering for Melter Technology (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Plasma arc torch devices.	**Advantages:** Minimization of residual waste. State of development of technology. Impact of system failure. Additional treatment requirements. Flexibility in accepting feed with variable chemistry. Requirements for physical pretreatment of waste. Relative product quality. Ease of operation. Ability to accept other wastes. Smaller off-gas flow perceived as less difficult to treat relative to FFHCM. **Disadvantages:** No mechanical availability. No maintainability. No energy conservation. Very high cost relative to FFHCM (+50%), Very high plasma temperature could cause increased volatilization of heavy metals and arsenic.	

TABLE 6.3.3-1 Results of Modified Value Engineering for Melter Technology (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
	Joule-heated ceramic melters.	**Advantages:** Requirements for physical pretreatment of waste. Mechanical availability. Maintainability. Smaller off-gas flow perceived as less difficult to treat relative to FFHCM. **Disadvantages:** No minimization of residual waste. State of development of technology. Additional treatment requirements. No flexibility in accepting feed with variable chemistry. Relative product quality. Ease of operation. Energy conservation. Ability to accept other wastes. Very high cost relative to FFHCM (+50%); Melt immiscibility problems related to the use of sodium based additives likely to cause product from JHCM treatment of WSS wastes to fail TCLP.	

TABLE 6.3.3-2 Observational Method for the Evaluation of Melter Technology

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Fossil fuel-heated ceramic melters.	Size reduction required to minus 1 mm. (nominal).	Less size reduction required.	Moderate	None. Can reduce intensity of crushing/grinding required (e.g., adjust grinders to larger particle size as undersize), current design will still work.
		More size reduction required.	Very Low	None. Can increase intensity of the use of the crushing/ grinding circuits (e.g., adjust grinders to smaller particle size as undersize), current design will still work.
		Much less size reduction required.	Very Low	Minor. Could eliminate grinder and use an impact mill or other device that can produce a finely crushed, but not finely ground, material.

TABLE 6.3.3-2 Observational Method for the Evaluation of Melter Technology (Continued)

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
	Drying of wastes required to 99% solids (nominal).	Less drying required.	Moderate	Minimal. Melter system will likely be able to handle a more moist feed material with minimal feed connection changes, but storage circuits might have to be redesigned to accommodate moisture (e.g., stickiness of sludge would cause clumping and possibly cementation of raffinate in silos and, therefore, other storage such as another covered pile, might be used). If very wet raffinate (say 27% solids) is used, tanks for storage and pumping equipment to transfer the material to the melter would be required. If this option is chosen, other impacts to the vitrification circuit would occur (melter sizing, storage and blending, feeding, and off-gas treatment circuits).
		More drying required.	Extremely Low	None. Material is already assumed to be "bone dry".
	Energy requirements other than $4.0x10^6$ to $5.0x10^6$ Btu/ton.	Higher energy requirements.	Very Low	None. Increase fuel and air input to melters.
		Lower energy requirements.	Very Low	None. Decrease fuel and air input to melters.

TABLE 6.3.3-3 Data Quality Objectives for Melter Technology

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Less size reduction required. More size reduction required. Much less size reduction required. Less drying required. More drying required. Higher energy requirements. Lower energy requirements.	Intensity of size reduction required.	What is the technical, optimal, and cost-effective size reduction required for melting?	Conduct further testing- preferably engineering- and pilot-scale testing with the melter morphology selected to determine sizing requirements, trade-offs with respect to throughput and melter size and pretreatment requirements.
	Intensity of drying required.	What is the technical, optimal, and cost effective moisture content required for melting?	Conduct further testing- preferably engineering- and pilot-scale testing with the melter morphology selected to determine sizing requirements, trade-offs with respect to throughput/melter size and pretreatment requirements.
	Energy requirements.	What is the energy requirement window for treatment of WSS wastes with an FFHCM?	Conduct engineering- and pilot-scale testing with the melter morphology selected to determine energy requirements.

TABLE 6.3.3-4 Results of Modified Value Engineering for Additives and Waste Mixtures

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Produce glass that passes TCLP. Produces melt and glass with miscible phases. Produces melt in necessary viscosity ranges. Produces melt in necessary temperature ranges. Minimizes residual waste. Cost.	No additives used; raffinate and soil/clay mix will be used.	**Advantages:** Minimizes final waste tonnage, volume, and residual waste; no additives to be delivered, prepared, stored, and mixed; no sulfate miscibility problems; low cost- do not have to purchase additives. **Disadvantages:** None.	No additives and reagents - blend soil and clay with raffinate.
	Crushed lime/waste glass (simple/nonstandard glass forming additives).	**Advantages:** Readily available; inexpensive; no sulfate immiscibility problem. **Disadvantages:** Increases final waste tonnage and volume.	
	Sodium; lithium, ± borate, glass sand, high quality alumina (complex/high quality/standard glass forming additives).	**Advantages:** None. **Disadvantages:** Creates significant sulfate immiscibility problem that could cause waste form to fail TCLP; increases final tonnage and volume of waste form; high cost.	

TABLE 6.3.3-5 Observational Method for the Evaluation of Additives and Waste Mixtures

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
No additives and reagents, use mix of raffinate and soil/clay.	Adequate raffinate to blend with soil/clay.	Insufficient raffinate.	Moderate	Change ratio of raffinate to soil/clay OR use simple additive such as crushed lime as an additional flux.
	Adequate soil/clay to blend with raffinate.	Insufficient soil/clay.	Low	Change ratio of raffinate to soil/clay OR use other site soils, soil from off-site, or waste glass for silica and alumina source.

TABLE 6.3.3-6 Data Quality Objectives for Additives and Waste Mixtures

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Insufficient raffinate or soil/clay.	Insufficient raffinate or soil/clay.	Determine acceptable ratios of raffinate to soil/clay blends that will produce a melt with the required melting characteristics and a final glass with the required stability (passes TCLP).	Conduct further bench-scale crucible melt tests and further test the blends during engineering- and pilot-scale testing.

TABLE 6.3.3-7 Results of Modified Value Engineering for Material Preparation

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Produces a consistant (weight and moisture) feed for the melter. Produces a material that is easy to handle. Produces a material that is easy to blend. Cost.	Thoroughly dry and reduce particle size of waste materials.	**Advantages:** Consistant feed material; easy to blend; does not cause large quantity of superheated steam during melting; level of confidence is added to vitrification process as commercial glass industry uses dry and fine particulate materials for melter feed; equipment required is commonplace and easy to operate; conserves energy; low cost. **Disadvantages:** Labor intensive; more unit processes.	Dry and reduce particle size of waste materials.
	No preparation - feed wastes as received (raffinate) or with minimal screening (soils).	**Advantages:** Fewer unit processes; less labor intensive. **Disadvantages:** Very difficult to control quality and mixture of waste materials as feed to melters; clay would be impossible to feed; no existing analogous process in related industry; large quantity of superheated steam would be generated; energy intensive; high cost.	

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TABLE 6.3.3-8 Observational Method for the Evaluation of Material Preparation

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Thoroughly dry and reduce particle size of waste materials.	Raffinate and soil/clay available for treatment at ≤20% moisture.	Raffinate dewatered to <80% solids or soil/clay delivered to vitrification facility at <80% solids.	Moderate (raffinate) Low (soil/clay)	Drying equipment can handle some variability in moisture content; if moisture exceeds equipment capacity as designed, we would need to increase capacity of dryers or reduce throughput and extend operating period.
	Waste material, as delivered to vitrification facility, is easy to comminute.	Waste material is less friable than expected.	Low	Comminution equipment can handle some variability in friability; if material is significantly less friable than anticipated, the addition of other staged comminution equipment may be necessary or reduce the throughput and extend operating period of comminution equipment.

TABLE 6.3.3-9 Data Quality Objectives for Material Preparation Circuits

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Soil/clay is >20% moisture as received at vitrification facility. Raffinate is >20% moisture as received at vitrification facility. Soil/clay and dewatered raffinate is less friable than expected.	Raffinate is dewatered to <80% solids.	What is the actual range of solids content that can be achieved through physical dewatering of the raffinate?	Conduct engineering- or pilot-testing of dewatering systems proposed to determine dewatering effectiveness. Conduct engineering- or pilot-testing of drying equipment proposed to determine range of drying possible.
	Soil/clay, as received and dried, and dewatered and dried raffinate is less friable than expected.	What is the friability of the waste materials at various appropriate stages of dryness?	Conduct bench-scale testing of the friability of the waste materials at various stages of dryness.

TABLE 6.3.3-10 Results of Modified Value Engineering for Product Discharge Circuits

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Safety and ease of handling product. Exacerbation of potential immiscibility or crystallization problems. Minimizes number of unit processes. Energy efficiency. Cost.	Discharge molten glass to a quench reservoir and generate a granular or "fritted" product.	**Advantages:** Product is cool and therefore safer and easier to handle; similar to earth materials and can be handled and placed like soil; "freezes" melt minimizing crystallization and formation and exsolution of immiscible phases should they exist; simple process with few unit processes; annealing heat and storage unnecessary; energy efficient; low cost. **Disadvantages:** None.	Fritted product.
	Shape, form, or containerize product.	**Advantages:** Containerized product would provide another level of protection of the product from the environment (not necessary as contaminants are adequately destroyed or immobilized in the glass and the glass will be placed in the disposal cell or buried). **Disadvantages:** Product likely to be less physically stable in the environment and could explode due to stress relief; extra unit processes required; specialized handling equipment required; less energy efficient; higher cost.	

TABLE 6.3.3-11 Observational Method for the Evaluation of Product Discharge Circuits

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Fritted Product.	Product will be a fine to coarse grained angular material.	Grain size may be significantly larger than anticipated.	Low	None. Increase cooling water volume, decrease cooling water temperature, decrease melter flow rate.
		Grain size may be significantly smaller than anticipated.	Low	None. Decrease cooling water volume, increase cooling water temperature, increase melter flow rate.
	Product has sufficient strength to ensure physical stability of the disposed waste.	Strengths are significantly lower than expected.	Moderate	May require changes in the method of waste placement and compaction.
		Strengths are significantly higher than expected.	Moderate	None.

TABLE 6.3.3-12 Data Quality Objectives for Product Discharge Circuits

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Grain size may be significantly larger than anticipated. Grain size may be significantly smaller than anticipated. Product strengths are significantly lower than expected. Product strengths are significantly higher than expected.	Product strengths are significantly lower than anticipated.	What are the physical characteristics of the fritted product (including compressive strength).	Conduct bench-, engineering-, and pilot-scale testing programs to produce vitrified product and then test that product to determine the physical characteristics of the fritted product.

TABLE 6.3.3-13 Results of Modified Value Engineering for Off-Gas Treatment Technology

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Control efficiency for volatile metals (30.5).	Low pressure drop venturi/tandem nozzle scrubber (TNS)	**Advantages:** Control efficiency of particles and acid gases, state of technology, general safety.	The five alternatives appear to be acceptable for our application. The Quench Scrubber/Spray Dryer/Dry Venturi/Baghouse system was chosen as incrementally superior to the others because of acid gas control and the amount of residual waste produced. The Tandem Nozzle and Collision Scrubber and the Ionizing Wet Scrubber also could be used very successfully in this application.
Control efficiency for particles prior to HEPA filters (30.0).	Low pressure drop venturi/collision scrubber (COLS).	**Advantage:** Control efficiency of particles and acid gases, state of technology, general safety.	
Mechanical availability of the system (26.5).	Low Pressure Drop Venturi/Centrifugal Scrubber/Wet Electrostatic Precipitator (CENS/WESP)	**Advantages:** Control efficiency of particles.	
General safety (26.5).	Low pressure drop venturi/ionizing wet scrubber (IWS).	**Advantages:** Control efficiency of particles and operability of system.	
Control efficiency for mercury (25.5).	Quench scrubber/spray dryer/dry venturi/baghouse (SD/DV/B).	**Advantages:** Control efficiency for volatile metals and particles, minimal residual waste produced.	
Residual waste produced (24.0).	Low pressure drop venturi/packed bed scrubber (PBS).	**Advantages:** Control efficiency for acid gases and particles, state of technology.	

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TABLE 6.3.3-13 Results of Modified Value Engineering for Off-Gas Treatment Technology (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Control efficiency for volatile metals (30.5).	Low pressure drop venturi/tandem nozzle scrubber (TNS)	**Advantages:** Control efficiency of particles and acid gases, state of technology, general safety.	The five alternatives appear to be acceptable for our application. The Quench Scrubber/Spray Dryer/Dry Venturi/Baghouse system was chosen as incrementally superior to the others because of acid gas control and the amount of residual waste produced. The Tandem Nozzle and Collision Scrubber and the Ionizing Wet Scrubber also could be used very successfully in this application.
Control efficiency for acid gasses (21.0).	Spray dryer/fabric filter (SD/FF).	**Advantages:** State of technology. **Disadvantages:** General safety.	
Operability of system (21.0).	Spray dryer/electrostatic precipitator (SD/ESP).	**Disadvantages:** State of technology.	
Ease of adding NO_x control (16.5).	Spray dryer/baghouse/low pressure drop venturi (SD/B/LPV).	**Advantages:** Control efficiency for particles and acid gases, state of technology. **Disadvantages:** Mechanical availability, operability, ease of adding NO_x control.	
State of technology (13).	Spray dryer/baghouse/high pressure drop venturi (SD/B/HPV).	**Advantages:** Control efficiency for particles and acid gases, state of technology. **Disadvantages:** Mechanical availability of system.	
	Low pressure drop venturi/wet electrostatic precipitator/low pressure drop venturi/ionizing wet scrubber (WESP/IWS).	**Advantages:** Control efficiency for particles. **Disadvantages:** Operability, state of technology.	

TABLE 6.3.3-13 Results of Modified Value Engineering for Off-Gas Treatment Technology (Continued)

Evaluation Criteria	List Alternatives	Advantages/Disadvantages	Preferred Alternative
Control efficiency for volatile metals (30.5).	Low pressure drop venturi/tandem nozzle scrubber (TNS)	**Advantages:** Control efficiency of particles and acid gases, state of technology, general safety.	The five alternatives appear to be acceptable for our application. The Quench Scrubber/Spray Dryer/Dry Venturi/Baghouse system was chosen as incrementally superior to the others because of acid gas control and the amount of residual waste produced. The Tandem Nozzle and Collision Scrubber and the Ionizing Wet Scrubber also could be used very successfully in this application.
	Air or spray cooling/dry scrubber/cyclone/electrostatic precipitator/fabric filter (DS/C/ESP/FF).	**Advantages:** Control of volatile metals. **Disadvantages:** General safety, state of technology.	
	Submerged bed/packed tower (SB/PT).	**Advantages:** Mechanical availability.	

TABLE 6.3.3-14 Observational Method for the Evaluation of Off-Gas Treatment Systems

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
Quench scrubber/spray dryer/dry venturi/baghouse (SD/DV/B).	Carry-through from the melter to the off-gas system is .5% of feed rate.	Carry-through may be as high as 3%.	Low to Moderate	Higher amount of particulate in the waste stream to be treated. The amount of solids recycled by the first srubber will increase.
	Off-gas temperature is 1500°C and the flow is 16,300 ACFM.	Off-gas temperature and flow vary with time.	Low to Moderate	Variations in flow rate will be minimized by adding clean "make-up" air.
	Actual chemical composition of waste feed material is similar to that expected from sampling results and anticipated waste blending ratios.	Contaminant concentrations are higher. Contaminant concentrations are lower.	Low to Moderate Low to Moderate	Higher concentrations of volatile metals will increase amount of unrecyclable sludge. Higher acid gasses will increase amount of reagents needed for neutralization. Lower concentrations will reverse this.
	Recuperator supplied by the melter vendor will be adequate and will not have plugging problems due to deposition.	Plugging of the recuperator is excessive.	Moderate	If the recuperator plugs, a non-fouling quench scrubber will need to be used. The loss of the recuperator would result in some loss of energy to the melter/off-gas system.
	Excess air rate for the melter is 20%.	Excess air rate is as low as 5%.	Moderate to High	Excess air reduction would reduce the off-gas volume and the amount of NO_x generated. The NO_x control equipment may become unnecessary and the off-gas treatment equipment could be downsized.

TABLE 6.3.3-14 Observational Method for the Evaluation of Off-Gas Treatment Systems (Continued)

Component Preferred	Expected Condition	Potential Deviation	Probability for Occurrence	Affect on Design
	Radon is controlled in the material preparation circuits.	Radon cannot be controlled in the material preparation circuits.	Low	If radon cannot be controlled in the feed preparation circuit, control would be needed in the off-gas stream. The large volume of gas makes the usual radon control alternative of activated carbon quite costly and unfeasible.
	Waste from primary scrubber can be recycled back to the melter	Primary scrubber waste cannot be recycled.	Low	If residuals from the primary scrubber cannot be recycled, there would be an increase in the amount off-gas treatment system waste requiring further treatment.
	Waste from secondary scrubber cannot be recycled back to the melter	Secondary scrubber waste can be recycled.	Low	The current design assumes that secondary scrubber waste cannot be recycled. If residuals from the secondary scrubber can be recycled, the off-gas system would not produce any waste requiring further treatment.

TABLE 6.3.3-15 Data Quality Objectives for Off-Gas Treatment Circuits

List of Potential Deviations	Potential Deviations Affecting Design	Specific Questions to be Answered	Data Collection Activities
Particulate carryover may be as high as 3%.	Particulate carryover may be as high as 3%.	What is the amount of particulate carryover from the melter to the off-gas stream?	Conduct further bench-scale testing to determine waste blending ratios, melting temperatures, and other factors influencing melter operation. Then conduct integrated melter and off-gas engineering and pilot-scale testing programs to answer these questions regarding off-gas treatment circuits.
Off-gas temperatures and flow may vary with time.	Off-gas temperatures and flow may vary with time.	What are the operational ranges of temperature and off-gas flows that are likely during treatment?	
Actual chemical composition of waste feed material is similar to that expected from sampling results and anticipated waste blending ratios.	Actual chemical composition of waste feed material is similar to that expected from sampling results and anticipated waste blending ratios.	What will be the mixing ratios of quarry and raffinate waste?	
Plugging of the recuperator is excessive.	Plugging of the recuperator is excessive.	Will the recuperator provided by the melter vendor have problems with plugging?	
Excess air rate is as low as 5%.	Excess air rate is as low as 5%.	What will the operational excess air rate of the melter?	
Radon cannot be controlled in the material preparation circuits.	Radon cannot be controlled in the material preparation circuits.	Will radon control be possible in the material preparation circuits?	
Primary scrubber waste cannot be recycled.	Primary scrubber waste cannot be recycled.	Can primary scrubber waste be recycled to the melter?	
Secondary scrubber waste can be recycled.	Secondary scrubber waste can be recycled.	Can secondary scrubber waste be recycled to the melter without causing volatile metals concentrations to build-up in the material feed.	

TABLE 6.3.3-16 Additives Used and Residual Waste Generated for Wet and Dry Off-Gas Treatment Systems

		Wet/Dry			
Waste Feed Input Stream	Unrecyclables	System	Urea (lbs/hr)[d]	Acid Gas Reagent (lbs/hr)	Unrecycled Material (lbs/hr)
125 tons/d Case I[a]	High	Dry Wet	67.4 67.4	215.1 197.2	140.4 140.4
125 tons/d Case I	Low	Dry Wet	189.4 189.4	167.8 153.8	76.8 76.8
125 tons/d Case II[b]	High	Dry Wet	91.9 91.9	362.3 332.1	240.5 240.5
180 Tons/d Case II[c]	High	Dry Wet	186.5 186.5	629.2 576.8	412.8 412.8

(a) Weighted average concentrations of constituent in quarry soils and raffinate sludge.
(b) Highest raffinate sludge pit average with average quarry waste concentrations.
(c) Highest average concentrations plus one standard deviation from the raffinate pit and the highest average quarry concentrations.
(d) All weights are dry weights.

TABLE 6.3.4-1 Size Reduction Material Identification

Material Type	Reduction Requirements
GROUP 1 — FRIABLE ASBESTOS-CONTAINING MATERIAL (ACM)	
Floor, wall, ceiling, window. Equipment mastics. Dry wall compounds (samples no ACM detected). Floor leveling compounds, underlayments. Floor tile, lab equipment ACM rope. Pipe joints, pipe insulation. Tank insulation, bricks (ACM). HVAC insulation. MAN MADE MINERAL FIBER MATERIAL Fiberglass insulation. Rockwool insulation. Equipment filters. Acoustical ceiling tiles. Acoustical wall tiles.	No reduction is required. All material to be handled as specified in Work Package 256, Technical Specification Section 02055 and 02063.

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TABLE 6.3.4-1 Size Reduction Material Identification (Continued)

Material Type	Reduction Requirements
GROUP 2 — EQUIPMENT MATERIAL	
Vehicles. Engine blocks. Air handling. Exhaust fans. Lathes. Coring equipment. Blending vessels. Other similar type equipment. EQUIPMENT WITH SHEET METAL SURFACES Cars, trucks, locomotive. Lab and process equipment. Hoods and vents. Boilers. Dry transformers. MCC and power panels. Dust collection. Reactor and reduction furnaces. Other similar type equipment.	Place intact. Remove all projections and coverings that might hinder later filling of void spaces. All material to be handled, sorted and stored as specified in Work Package 255, Technical Specification Section 02055.
GROUP 3 — STAINLESS STEEL	
Tanks. Equipment structural members. Pipe. Sheeting.	See removal procedures for groups 2, 4, 12, and 13 as applicable.
GROUP 4 — PIPES	
Pipe less than 12 in. in outside diameter with fittings, valves, and appurtenances intact. Pipe greater than 12 in. in outside diameter with fittings, valves, and appurtenances removed. Product process pipe.	8 ft lengths. 8 ft lengths and split in half. 8 ft lengths and in roll-off boxes. 8 ft lengths (12 in. O.D. larger split in half, 12 in. O.D. smaller 20 ft lengths).

TABLE 6.3.4-1 Size Reduction Material Identification (Continued)

Material Type	Reduction Requirements
GROUP 5 — MISCELLANEOUS METALS	
Pipe fittings, valves and short curved pipe. Bolts and nuts. Castings. Electrical connectors, light fixtures and ballasts. Small pieces of equipment. Sag rods and reinforcing steel. Fence posts/fencing.	Sort removed projections and place in appropriate material groups 1-19.
GROUP 6 — NON-METAL DEBRIS	
Plastic. Glass. Paper products. Floor scrapings. General trash. Collected debris (housecleaning). Housecleaning HEPA vacuum dust.	Place in roll-off boxes. Crush composite material to minimize voids. Double bag and label bags "Radioactive Material." Place in roll-off boxes and label as "Bagged Material."
GROUP 7 — SHEET METAL	
Metal desks and file cabinets. Supply closets and lockers. Ductwork and control boxes. Man-doors.	Flatten all equipment made primarily of sheet metal. Size flatten sheet metal in 4 ft x 8 ft pieces.
GROUP 8 — PBC CONTAMINATED MATERIAL	
Equipment. Concrete. Pipe. Miscellaneous contaminated material.	Sizing, removal and transportation as specified in WP 255, Technical Specification Section 01712.
GROUP 9 — SELECT MATERIALS	
Oils. Thorium compounds. Yellow cake and green salt. Mercury.	Place in 55 gallon drums.
GROUP 10 — NONFRIABLE ACM	
Siding sheets. Miscellaneous nonfriable ACM. Shielding sheeting. Partitions.	Band in 4 ft bundles and stack on dunnage.
GROUP 11 — ACM	
Built-up roofing with concrete roof decking (lightweight concrete).	Sizing, removal and transportation as specified in WP 255, Technical Specification Section 02083.

TABLE 6.3.4-1 Size Reduction Material Identification (Continued)

Material Type	Reduction Requirements
GROUP 12 — STRUCTURAL STEEL	
Columns. Beams. Crane rail. Girts. Purlins.	Approximate maximum 30 ft lengths or maximum 5000 lb weight limit. Remove projections to within 1 ft of steel shapes.
GROUP 13 — PLATE STEEL	
Metal decking. Expanded metal decking. Towers. Tanks and vessels and plate metal. Corrugated steel siding and roofing.	Plate steel; remove in approximate 4 ft x 8 ft pieces. 3/8 in. larger to nonshreddable. 3/8 in. small to shreddable. Siding, roofing in 4 ft x 8 ft x 4 ft bundles.
GROUP 14 — RUBBLE	
Suspended concrete slabs. Cinderblock. Porcelain. Masonry.	Rubblize concrete with dimensions greater than 3 ft.
GROUP 15 — RAILROAD RAILS	
	Deconnable.
GROUP 16 — LARGE WOOD PIECES	
Telephone poles. Railroad ties. Wood desks and chairs. Coat racks. Man-doors and partitions. Miscellaneous wood materials.	Flatten all wood material as applicable. Flatten chip and or mulch.
GROUP 17 — WOOD (SPECIAL)	
Cooling tower (Building 413).	Mulched and loaded into roll-off boxes.
GROUP 18 — MISCELLANEOUS NON-METALS	
Graphite pipe and sheeting. Diatomaceous earth.	No reduction is required. Trash and miscellaneous non-metals.

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TABLE 6.3.4-1 Size Reduction Material Identification (Continued)

Material Type	Reduction Requirements
GROUP 19 — METALS (SPECIAL)	
Aluminum. Siding. Deck plate. Structural shapes.	No reduction is required.
Lead. Shielding. Scale weights. Drain pipe seals.	No reduction is required.
Copper. Bus bars. Wire conductors, conduit and motors.	No reduction is required.

TABLE 6.3.5-1 Material Balance for Dewatering Plant

1. Estimated quantities of raffinate sludges

Item	Pit 1	Pit 2	Pit 3	Pit 4	Total
Raffinate sludge, dry weight basis, ton	4,700	4,700	35,000	15,000	59,400

Dredge operations:

Feed from dredge to dewatering plant: 15% solids/85% water
Schedule: 16 hr (two 8-hr shifts)
Effective production: 14.5 hr/d
Operate dredge: 5 d/wk
Annual operation: 9 mo/yr

2. Material balance based on CSS and VIT plant needs

Item	Feed rate from dredge to dewatering plant, ton/hr (tph) 15% solids/85% water.	Feed rate from dewatering plant to CSS plant, tph grout-like material 27% solids/73% water.	Feed rate from dewatering plant to CSS plant, tph soil-like material 38% solids/62% water.	Feed rate from dewatering plant to VIT plant, tph 80% solids/20% water.
Option 1	102.6 tph slurry. 15.4 tph solids. 87.2 tph water.	57 tph sludge. 15.4 tph solids. 41.6 tph water.		
Option 2	92 tph slurry. 13.8 tph solids. 78.2 tph water.		36.4 tph sludge. 13.8 tph solids. 22.6 tph water.	
Option 3	40 tph slurry. 6 tph solids. 34 tph water.			7.5 tph sludge. 6 tph solids. 1.5 tph water.

TABLE 6.3.5-2 Functions of the Raffinate Sludge Dewatering Devices

Processing Equipment	Functional Purpose	Measurable Parameters
Metals separator (Optional)	To separate the iron and steel debris from the sludge.	None; the metal objects will simply be removed.
Classifier	To separate the oversized solid particles from the raffinate sludge by tumbling and rotating the sludge in a contained cylinder and allowing the middling and fine materials to pass through different size screening media and then pump to storage.	The density of the slurry can be measured. The oversized materials can be separated and transferred to a storage area. The takeoff from the screens can be determined visually and the sizes selected.
Agitated storage tank (Optional)	The agitated storage tank may be needed to buffer and stabilize the flow from the classifier. Due to the variable pump rates of the dredge, the feed rate would be non-uniform and the process controls may not be maintained.	Slurry samples collected at the storage tank inlet can be used to determine if the slurry contains too much oversized materials.
Auger/mixer (Optional)	The slurry is pumped to the auger/mixer where the solids are mixed and blended with an initial dose of flocculent (about 1/4 of the calculated amount). Bench-scale studies have determined that the mixing of flocculants is extremely critical and minimizes the amount needed for this reaction.	The physical appearance of the pre-flocculated solids can be determined at this stage.
High-capacity thickener (HCT)	The HCT is designed with a special weir for the addition of flocculent. To maximize the flocculating characteristic of these solids, the remaining flocculant is fed at this stage. The unique motor drive and mechanism of the HCT will help form a densely flocculated sludge with a short settling period.	The flocculated solids can be sampled and settling time curves can be plotted.
Belt press filtration for CSS	If the feed material specifications for the CSS plant require a dewatered sludge, the underflow of the thickener (flocculated solids) is fed to a belt press. The water is squeezed out as the sludge is transported by a belt over a series of pressure rollers.	The filter cake can be sampled, and the total water content measured. If the material is too dry, the pressure on the rollers can be decreased. If too wet, the pressure can be increased.
Belt expressor press filter for VIT	If the feed material specifications for the VIT plant require a dewatered sludge, the underflow of the thickener (flocculated solids) is fed to a belt expressor press. The expressor works on the same principle as the belt press, but exerts a greater roller pressure on the sludge cake, thus producing a drier cake.	The filter cake can be sampled and the total water content measured. If the material is too dry, the pressure on the rollers can be decreased. If too wet, the pressure can be increased.

TABLE 6.3.5-2 Functions of the Raffinate Sludge Dewatering Devices (Continued)

Processing Equipment	Functional Purpose	Measurable Parameters
Radon emission control system including detection and monitoring devices	The RECS will be designed to take off vapors at the classifier, storage tank, and augar/mixer. Gas will be sucked through a duct system through a central header and passed over a desiccant and then a carbon adsorber. The radon will be collected by the carbon and retained until it decays. After the carbon is exhausted or spent, it can be fed to the CSS or VIT treatment plant.	Radon measurements can be taken at each process unit and at the final venting to the atmosphere stage.

TABLE 6.4-1 Sources and Volumes of Materials to be Removed

Source	Item[a]	Quantity[b]	Unit
TSA[c]	Pad		
	• Gravel	31,405	yd^3
	• Concrete	50	yd^3
	Concrete barriers	460	lf
	Liner		
	• Synthetic	108,150	yd^2
	• Bentonite	3,672	yd^2
	Fence	670	lf
	Backfill	18,870	yd^3
	Pipe		
	• HDPE	3,529	lf
	• Metal	431	lf
	Siding and roofing	530	ft^2
	Miscellaneous structural steel	1,140	lbs
	Miscellaneous equipment	10	yd^3
CMSA	Gravel	32,300	yd^3
	Drainage structures	10	ea.
	Drainage pipe	2,000	lf
	Riprap	10	yd^3
WTP & Ponds[c]	Metal siding/roofing	19,000	ft^2
	Structural steel	61	tons
	Interior partitions/ceiling	6,600	ft^2
	Piping		
	(metal)	2,000	lf
	(PVC)	2,800	lf
	(CMP)	625	lf
	(miscellaneous)	5	yd^3
	Concrete	250	yd^3
	Gravel	2,700	yd^3
	Liner		
	(synthetic)	21,000	yd^2
	(bentonite)	4,800	yd^2
	Riprap	605	yd^3
	Backfill	17,000	yd^3

TABLE 6.4-1 Sources and Volumes of Materials to be Removed (Continued)

Source	Item[a]	Quantity[b]	Unit
Waste Treatment Plant[c]	Metal siding	1,400	yd^3
	Structural steel	100	tons
	Concrete	389	yd^3
	Gravel	195	yd^3
	Backfill	467	yd^3
Roads/Parking[c]	Asphalt	1,258	yd^3
	Concrete	27	yd^3
	Gravel	4,715	yd^3
	Piping		
	(PVC)	320	lf
	(metal)	45	lf
	Culverts (CMP)	675	lf
	Backfill	6,927	yd^3
Decontamination Pads[c]	Pad		
	(concrete)	121	yd^3
	(gravel)	74	yd^3
	Underground pipe	TBD	lf
	Miscellaneous metals	4	yd^3
Site Miscellaneous	Fencing	2,845	lf
	Drainage pipe	2,000	lf
	Drainage structures	30	ea.
	Topsoil placement	15,000	yd^3

PVC = polyvinyl chloride
CMP = corrugated metal pipe
HDPE = high-density polyethylene

Notes:

Equipment from waste treatment plant and the site water treatment plant is considered to be decontaminated and salvageable.

(a) Miscellaneous items not mentioned are considered to be incidental to the respective source.
(b) Quantities represent order-of-magnitude estimate. A more accurate estimate will be performed prior to final design.
(c) Potentially contaminated materials.

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TABLE 6.5-1 Possible Breakdown of Subcontracts for Large and Small/Disadvantaged Businesses

Number	Activity	Possible Small or Disadvantaged Business
1	Health physics technicians	Yes
2	Quality control technicians	Yes
3	Install wells	Yes
4	On-site laborers	Yes
5	Construction equipment decontamination facility	Yes
6	Operate equipment decontamination facility	Yes
7	Clear and grub raffinate pit area, construct roads	Yes
8	Construct water detention/retention basins	Yes
9	Construct Ash Pond soil system	Yes
10	Remove building foundation, backfill, excavate cell foundation	No
11	Construct construction materials staging area (CMSA)	Yes
12	Construction site roads	Yes
13	Surveying	Yes
14	Construct CSS pilot plant	Yes
15	Construct CSS waste treatment facility	No
16	Construction site WTP Train II	No
17	Construct facilities for Train II	Yes
18	Operate raffinate pit pumping facility	Yes
19	Operate WTP Trains I and II	Yes

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TABLE 6.5-1 Possible Breakdown of Subcontracts for Large and Small/Disdavantaged Businesses (Continued)

Number	Activity	Possible Small or Disadvantaged Business
20	Construct disposal cell: Build Phase I, II and Closure Excavate waste, dredge sludge, operate treatment facility, place waste in cell. Place cover.	 No No No
21	Construct borrow haul road	Yes
22	Develop clay borrow area	Yes
23	Operate clay borrow source	Yes
24	Construct Ash Pond soil system	Yes
25	Process wood (chipping)	Yes
26	Excavate/restore Army vicinity properties 1, 2, and 3	Yes
27	Excavate/restore Army vicinity properties 5 and 6	Yes
28	Excavate/restore Busch Conservation Area vicinity properties 3, 4, and 5	Yes
29	Excavate/restore Busch Lakes 34, 35, and 36	Yes
30	Remove Building 434	Yes
31	Site reclamation Chemical Plant Borrow	Yes
32	Maintain effluent discharge pipeline	Yes
33	Decontamination of structural steel Construct facility Operate facility	Yes

TABLE 8-1 Cell Performance Factors

System	Factors To Consider
Hydrology	• Flow/seepage of water and potential contaminants into, through, and from the cell • Routes of flow/seepage • Geochemical influences on seepage quality
Stability	• Behavior of soil and rock when acted on by natural forces, including: - water runoff (erosion) - gravity (deformation and slope stability) - geological change (geomorphological processes) - wind impact (Tornado)
Emissions	• Radon emissions through: - cover - clean-fill dike - leachate collection drains - transport in leachate • Thermal emissions: - effect on cover - effect on liner
Biology	• Vegetation rooting (growth, decay and toppling) • Animal intrusion • Human intrusion

TABLE 8-2 Disposal Cell Seepage Values (Gallons per acre per day)

Item	Route	0-5 Yr Period	5-50 Yr Period	50-200 Yr Period	200-1000 Yr Period
1.	Precipitation	2434.3	2453.2	2508.6	2514.9
2.	Surface Runoff	0.5	1.3	1.0	1.0
3.	Evapo-transpiration	2097.6	2036.6	2064.9	2079.2
4.	Cover Drainage	342.0	418.3	441.7	435.3
5.	Cover Infiltration	N/A	0.0	0.0	0.2
6.	Seepage through Waste	10.1	7.6	3.9	1.8
7.	LCRS Drainage	2500 --> 10.1	7.6	3.9	1.8
8.	Seepage from Cell	0.0	0.0	0.0	<0.1

Item numbers correspond with legend of Figure 8-1.

TABLE 8-3 Leachate Collection and Detection System Data for Cell No. 2

(Area 2.78 acres)				
	Volume (Gallons)			Precipitation (in.)
Date	CPA-1	CPA-2	CPA-3	
Sep-88	10000	--	--	--
Oct-88	10000	--	--	--
Nov-88	2255	--	--	--
Dec-88	3110	--	--	--
Jan-89	1130	10	180	1.07
Feb-89	1470	7	88	.64
Mar-89	985	4	75	2.18
Apr-89	0	1	48	.25
May-89	900	0	29	5.46
Jun-89	825	0	11	7.15
Jul-89	0	0	4	3.18
Aug-89	0	0	2.25	8.88
Sep-89	0	0	1	4.41
Oct-89	0	0	38	.56
Nov-89	240	0	0.4	0
Dec-89	0	0	0.3	.44
Jan-90	0	0	0.3	2.07
Feb-90	900	0	0.1	1.26
Mar-90	693	0	0.05	3.18
Apr-90	0	0	0.01	.98
May-90	520	0	0.01	2.85
Jun-90	275	0	0	4.17
Jul-90	250	0	0	1.2
Aug-90	0	0	0	2.41
Sep-90	230	0	0	3.44
Oct-90	0	0	0	.48
Nov-90	0	0	0	2.07

TABLE 8-3 Leachate Collection and Detection System Data for Cell No. 2 (Continued)

(Area 2.78 acres)				
	Volume (Gallons)			Precipitation (in.)
Date	CPA-1	CPA-2	CPA-3	
Dec-90	265	0	0	.43
Total	8683	22	477.4	58.8

Table 11-1

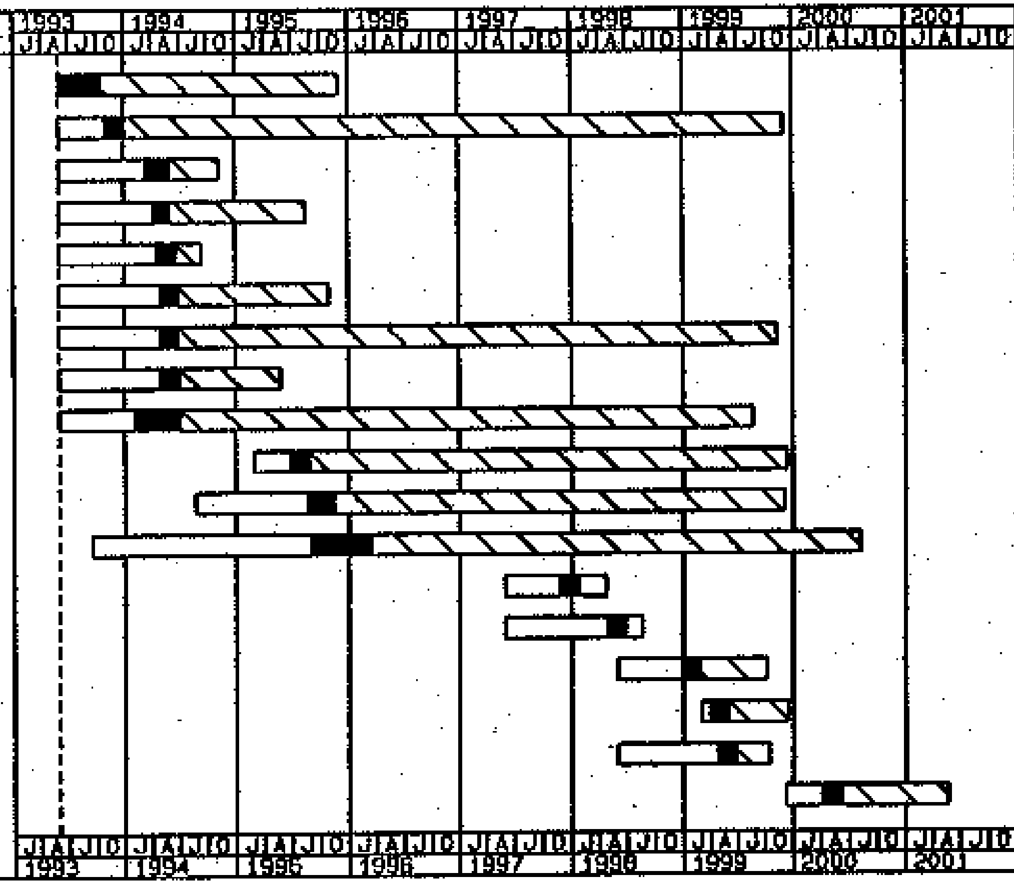
WORK PACKAGE SUMMARY

WSSRAP DE-AC05-86OR21548
MK-FERGUSON
CONTRACT: 3589

FILE: CSDSMSUM

CDR CSD SUMMARY SCHEDULE (1.1)

	ACTIVITY DESCRIPTION	ACT/FCS START CON	ACT/FCS FIN CONST
1	CONSTRUCT TRAIN II SWTP	18-OCT-93	30-NOV-95
2	CONST/OPER CSS PILOT PLANT	2-JAN-94	2-DEC-99
3	BORROW AREA DEVELOPMENT	30-MAY-94	8-NOV-94
4	DRAINAGE CONTROL	1-JUN-94	15-AUG-95
5	BORROW AREA HAUL ROAD	20-JUN-94	14-SEP-94
6	FOUNDATION REMOVAL	28-JUN-94	31-OCT-95
7	CONTAMINATED SOIL REMOVAL	29-JUN-94	9-NOV-99
8	CONSTRUCT CMSA	1-JUL-94	26-MAY-95
9	RAFFINATE PIT REMEDIAL ACTION	5-JUL-94	21-AUG-99
10	WASTE PROCESSING	26-AUG-95	12-DEC-99
11	CONSTRUCT AND OPERATE CSS PLANT	15-NOV-95	2-DEC-99
12	DISPOSAL CELL REMEDIAL ACTION	13-MAR-96	6-AUG-00
13	BUSCH PROPERTIES B3, B4, B5	25-JAN-98	23-APR-98
14	ARMY PROPERTIES A1, A2, A3	25-JUN-98	18-AUG-99
15	BUSCH LAKES 33, 34, 35	26-FEB-99	6-OCT-99
16	DISPOSAL OF LIQ WST @ OAK RIDGE	30-MAY-99	13-DEC-99
17	ARMY PROPERTIES 5, 6	25-JUN-99	14-OCT-99
18	SITE RESTORATION	7-JUN-00	20-MAY-01



ENGINEERING PROCUREMENT CONSTRUCTION (INCLUDES WINTER SHUTDOWN PERIODS)

ARTEMIS 9000 Barchart Drawing System 2:52 pm 17-JAN-94 Page 1 of 1

Table 11-2

Remedial Design and Remedial Action

Documents For Review

Site Operable Unit

RD / RA			EPA		MDNR	
P= Primary S= Secondary		Estimated date For Submittal	REVIEW REQUESTED COURTESY	OFFICIAL	REVIEW REQUESTED COURTESY	OFFICIAL
	Proposal of Deadlines for RD Work Plan	OCT 93				
P	**Remedial Design Work Plan (CDR) (DRAFT)**	MAR 94				
	Design Schedule	MAR 94				
	Detailed Description of Design Activities	MAR 94				
	Deadlines for "P" Documents	MAR 94				
	Target Dates for "S" Documents	MAR 94				
S	Pre Design					
	Field Sampling Plan					
S	Treatability Studies					
S	Design QAPP					
S	Construction Quality Control Plan					
P	**CSS pilot-scale Final design Submittal**	OCT 93				
	Foundation and Soil Removal 10% presentation					
	30% presentation					
S	**60% design Submittal**					
P	**Final Design Submittal**					
	CSS facility 10% presentation					
	30% presentation					
S	**60% design Submittal**					
P	**Final Design Submittal**					
	Disposal cell 10% presentation					
	30% presentation					
S	**60% design Submittal**					
P	**Final design Submittal**					
P	**Remedial Action Work Plan**					
	Substantial Continious Physcial on Site Activity	DEC 94				
S	Pre Final Inspection Report					
P	**Construction Completion Report**					
P	**Operations and Maintenance Plan**					

ITEMS IN BOLD PRINT ARE THOSE CONSIDERED ENFORCEABLE

Shaded areas are not applicible